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87 MILK STREET, BOSTON, MASS.

National Fire Protection Association.

(INTERNATIONAL.)

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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

Boston Photo News Co.

Inspector Pellegrino Muollo, an Italian speaking member of the Boston Fire Department, who patrols the North and West Ends. He tells the Italian children of the danger of just such accumulations of rubbish as are seen in the background of this picture, and through them reaches the parents. In the buildings surrounding this court, reached from the street only through a covered alley, live some five hundred people.

The Quarterly

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Street Obstruction by Automobiles.

Chief John C. McDonnell, that capable and serious minded official who has continually in view, and very rightly so, the possibilities of a serious conflagration in Chicago, has broken silence in a communication to the local transportation committee of the Chicago City Council on a matter that is becoming more or less of an obsession to the fire chiefs of all our cities, and which must continually impress any thoughtful pedestrian in a city street: the choking of our street areas by the parking of automobiles and the difficulty of clearing the streets of them for the operations of the fire department in case of a big, quick-spreading fire. Most cities prohibit parking at the curb within twenty-five or thirty feet of a hydrant, but this does not relieve the streets of congestion which frequently dangerously delays the fire apparatus in responding to downtown fires; nor relieve the firemen of the necessity of wasting precious moments in moving parked automobiles to make room for an effective handling of the apparatus. To safeguard cars against theft, special locks are provided, and when the fire occurs the owner of the parked car, the only person able to unlock it, may be at a matinee or in some remote part of the city.

The operated cars themselves present a sufficient impediment at certain moments, as was sufficiently demonstrated at a spectacular fire in Salt Lake City last year, which occurred about shop-closing time and attracted such a number of spectators in automobiles as to close several avenues of approach to the second-call apparatus. Although but a few blocks away, the trucks dodged about for fifteen minutes before gaining successful access to the fire area. This matter of street congestion is one to which traffic experts may very well give their prayerful attention. There is untold potential danger in it to every city in North America.

* * * * *

Street Obstruction by Snow.

There is another danger to all our cities in Canada and the Northern tier of States in the winter season — the obstruction of streets by snow. There is less danger in Canada than in the States, because heavy snow fall is habitual in Canada, and the cities are equipped to dispose of it. This is not true, however, of many cities in the States, which a sudden and violent storm may find, and has found, unprepared. The city of

New York last February was a conspicuous example. Neither its people nor its newspapers were properly alive to the great danger which existed for several days at that time. In the gossip column of the New York *Times* of February 13th some observant and thoughtful reporter wrote the following very pertinent paragraphs:

TOPICS OF THE TIMES.

A MENACE HARD TO EXAGGERATE.

That New York City at any time of untoward circumstances as to wind and weather might have a conflagration not less in proportion to its size than those which more than once have swept away large portions of other American towns is a warning that has often been made by men speaking as experts with full knowledge of conditions existing here. That is the same as saying that, until a far greater part of this city than now is composed of slow-burning or fireproof buildings, it is constantly menaced by the possibility of a fire so widespreading as to create an appalling loss of property and of life.

Never has there been better reason than now for every New Yorker to keep these facts in mind, for never, perhaps, except during the blizzard of '88, and for a day or two afterward, has the efficiency of our Fire Department been decreased as it has been for the last week by the inability of its members to reach fires promptly. And it is upon immediate attack that the efficiency of even the best of Fire Departments depends.

As everybody knows, there is a moment after which a burning building cannot be saved, but what is not so well known, or at any rate not so well realized, is that there is also a moment after which there is little chance of stopping what is called a conflagration, as distinguished from a fire, until it has consumed everything combustible in the direction toward which a strong wind happens to be carrying it. Chicago, San Francisco, Boston and Baltimore are among the cities that have suffered from such uncontrollable disasters, still well remembered, and their losses were trivial in amount in comparison with those surely to be incurred here if a great fire once were well started with our streets as nearly impassable as the majority of them are today.

UNPREPARED FOR GREAT EMERGENCIES.

In the presence of such a fire risk as has just been described, there are two things that New Yorkers can do at once—every one of them can use his utmost care and watchfulness in the protection of his own premises, residential and business, and he can do a little, if not toward clearing the streets of accumulated snow and ice, at least toward keeping them free of other obstructions wherever the clearing has been accomplished.

That is for the instant. There remains the larger task of creating and expressing an irresistible public demand for action by the municipal authorities in the way of better preparation for dealing with winter storms. Huge sums already are available for snow removal, but while money is, of course, essential for the performance of such work, money does not do it. For that there must be timely preparation for meeting emergencies which, though fortunately rare, have in them nothing of the unknown.

Most of our winters have at least one heavy snowfall, and yet under this administration, as under most of its predecessors, a really big and hard storm finds the city unable to prevent a more or less serious, and more or less prolonged, interruption of its vital activities. Usually, as now, the chief dependence has been on casual labor, hastily gathered, in insufficient amount, and the result is that what could be removed with comparative ease as snow turns to ice or an approach to it, and has to be assaulted with picks instead of shovels.

New York is not peculiar, of course, in habitually arranging for ordinary rather than for extraordinary demands, but its interest as well as its pride should cause it to guard itself better than it does from such costly

> and humiliating experiences as those through which it is now passing—lucky, too, that the experiences are no worse.

This is good stuff; very good stuff indeed; but had the editors of the *Times* been really alive to the critical danger that menaced the metropolis at the moment, it would have appeared under heavy headlines on the first page rather than in an inconspicuous column usually read by leisurely old ladies or by the tired business man after he has read everything else in the paper.

Members of the N. F. P. A. might very well make a note to call up the editors of their principal dailies and urge them, when such a condition again occurs, to tell their readers of the common peril and bespeak their utmost vigilance in seeing that no fires occur.

* * * * *

Carbon Tetrachloride Is Discussed. The almost simultaneous appearance of reports by Underwriters' Laboratories and the Bureau of Mines on the nature of the fumes or gases liberated by the application of carbon tetrachloride fire extinguishing liquids to fire is an interesting coincidence. Both reports are printed in this issue of the QUARTERLY. The genesis of one of them is as follows: In May, 1919, a small fire occurred in a machine shop in Seattle engaged largely in tool steel work. The fire was entirely in an annealing or tempering kettle with a hood and vent, but flamed through an opening in the hood, burning a window shade and cracking two panes of glass. The fire was extinguished by carbon tetrachloride extinguishers. What seemed to Fire Marshal Bringhurst, who reported the fire to us, an extravagant claim was made for damage said to have been caused to tool steel by the fumes of the fire extinguishers. Corrosive vapor, it was claimed, had so filled the room and affected the steel parts lying about that removal of the corrosion would reduce the dimensions of the parts, which were required for proper service, to be exact, to one three-thousandth of an inch.

A request was made of the Laboratories for an opinion, and Mr. Nuckolls' investigation is the result. It will be noted that the report goes beyond the original item of investigation and covers the field of research entered by the Bureau of Mines, and that the findings of both investigations are practically the same.

As to danger to the operators handling fire extinguishers projecting carbon tetrachloride liquids the reports are interesting, not because they demonstrate that such danger exists, but because they show that under any but extraordinary conditions it does not. People may be overcome by common wood smoke, and danger may reside in almost any mechanical device if it is not understood and handled with intelligence. The Bureau of Mines' paper is a bit of good workmanship. Certain of its suggestions seem, however, a bit extreme. Many hundred thousands of these carbon tetrachloride extinguishers are in use throughout the world. Few users of them will be inclined to buy a U. S. Army gas mask to hang up with them. Neither does the reported list of casualties from the use of these extinguishers seem imposing enough to inspire any extravagant fear of them. It is well for the public to know the properties of carbon tetrachloride, and this, thanks to the publication of these reports, they are now in a fair way of knowing.

A Conflagration of Words. We are familiar with the metaphor, "burning language," but in the sad grey world of today the ability to produce sentences deserving that appellation is eclipsed because of the modern habit of expressing all our ideas in superlatives. It was not so in the "seventies." Fifty years ago simple English words were able to carry the force and content their natural meaning indicated. This gave the inspired writer a chance to get his paragraphs into high light.

An apt illustration of this occurs in the Boston *Herald* of November 11th, 1872, which contains full details of the big Boston fire which had devastated the business district during the previous forty-eight hours. Under the caption, "The Ruins by Moonlight," some enraptured reporter wrote this:

> When the sun went down yesterday the fire fiend, who had slowly but surely wormed himself through the commercial loins of our city, eating out the very vitals of our trade and our industries, was chained, and the pale moon came slowly up to throw its lambient (sic) rays into smoky clouds that rose from the vast domain of smouldering ruins. Through the rolling volumes of smoke rose the blackened and ragged piles of brick and stone, and staggering over the debris of the desolation moved the dark figures of stalwart men like shadowy spirits in the storm clouds, while underneath the moving mass of smoke and vapor shown (sic) the bright but dying flames of the fiend's fury.

Evidently the *Herald* editor in those days was not the blasé and world-worn individual he now is. If a modern reporter were to bring in a line of stuff like that he would be consigned back to Harvard—to the School of Business Administration.

* * * * *

The False Fire Alarm. Anyone who takes a sufficient interest in fire departments to read the annual reports of the chiefs is impressed by the number of false alarms that are rung in from the street boxes every year. In certain cities gangs of mischievous boys perpetrating this nuisance have been broken up with greatest difficulty; and it frequently happens that some lonely individual, obsessed with a weak-minded desire to witness fire department runs, secretly sends in false alarms for a long time before he is apprehended. In catching offenders of this sort the Boy Scout fire squads are proving increasingly useful. These young conservators of fire safety are not long on such a job before the culprit is detected.

A false alarm with disagreeable results was rung in at Lynn last month by a recent arrival from Nova Scotia who had never seen a fire alarm box. He pulled the hook to see what would happen. In returning to headquarters from the box, hose wagon No. 1 met with an accident and plunged into the Saugus river, where it lay for many hours before it could be salvaged. This illustrates the serious side of these false calls. The departments may at any time be crippled by an accident; or the force at an important station unduly reduced at the critical time of a serious fire call by false calls to remote sections of a city.

Underwriters and the Fire Marshal's Office.

One of the most baffling aspects of the attempt to inform the public respecting the economic significance of the fire waste is the widespread, unintelligent notion that the only people logically interested in reducing the fire losses of the country are the fire insurance men. To make the people of the States and Provinces realize that the international ash-heap is their own affair and that they will be impoverished by it indefinitely unless they themselves move in the matter, seems a task almost superhuman. The Secretary of the N. F. P. A. has been speaking on this subject pretty constantly before all sorts of audiences for the past decade and declares that even at this date it is well nigh impossible to encounter a chairman who will introduce him to a meeting of a commercial body as a speaker on any other subject than "fire insurance."

Mr. O. B. Ryon, General Counsel of the National Board of Fire Underwriters, was recently addressed by a Denver, Colorado, correspondent on the subject of a fire marshal law for that state.

The Secretary of the N. F. P. A. happened into Mr. Ryon's office in Chicago while the reply to the inquiry was being dictated and Mr. Ryon's consent was obtained to print it in the QUARTERLY. Mr. Ryon's statements are frank and positive and should be helpful to the fire-prevention fraternity who are trying to induce the people to move in what is undeniably their own affair. The letter follows:

As a general proposition, we are friendly to a fire marshal law, and also it may be said generally the scheme is a good one, but, like a lot of other good schemes, it frequently fails, either in the law itself or in its administration.

Some of the people of the United States have an impression that it is the business of the fire insurance companies to reduce the fire waste, and if we create any agencies for this purpose, they ought to be paid for by the fire insurance companies.

Of course, it needs no argument to convince you that the fire waste is not a fire insurance company proposition. We probably would get along and make money if there were no water supply in any town or city, no fire department, and no fire marshal in any state. Fire insurance would adjust itself to the conditions as they existed, and charge for these conditions, and if the people desired to make the situation better, by fire fighting and fire prevention equipment, ordinances and laws, we would try to follow the betterment of conditions and reflect it in the credit which we would give in rates.

Theoretically, at least, it makes no difference to fire insurance as a whole whether there is a fire department in Denver or not, and it is equally theoretically true we do not care whether there is a fire marshal law in Colorado, and the only interest we perhaps ought to have in either of these propositions is the interest of any good citizen in the betterment of the conditions in the state and nation.

Practically, however, the situation seems to be otherwise, and we are spending a great many hundred thousand dollars annually of fire insurance company money, giving municipalities the benefit of our engineers, building construction experts, etc., etc., in an effort to convince the people they ought to do what seems such an obvious duty as to require no argument.

The same thing is true with fire marshal laws. A good many states seem to be willing to pass such laws, but are impressed with the idea that they are in the interest of the fire insurance companies, and ought to be paid for by a premium tax.

Again, the fire marshal's office is usually appointive, and subject to the infirmities of existing political conditions in every state, and a fire marshal, like an insurance commissioner, about the time he gets to be fairly good and efficient, yields to the exigencies of partisan politics and retires to private life.

I have copies of all the fire marshal laws in the country, and they are very much alike. A model which may be safely used, and a copy of which I enclose, is "The Suggested State Fire Marshal Law," prepared by the Fire Marshals' Association of North America. It can be easily adapted to any state, and is satisfactory to the insurance companies.

We are unalterably opposed to any fire marshal law which provides a premium tax for the support of the office, and this is not so much because of the tax as on account of the principle involved.

As above indicated, the reduction of fire waste in this country is not a problem for the fire insurance companies. Their business is to take the conditions as they find them and charge accordingly, and certainly they owe no direct duty to the public in the matter of reducing fire losses.

The people of the United States, property owners and insurers, the states themselves, the municipalities, and other political subdivisions, are the instrumentalities through which the fire waste can be reduced, and they ought to organize and maintain the machinery at public cost for this purpose.

If the problem itself can ever be rightly understood, and the utility of a fire marshal's office appreciated, I do not believe there will be any question but the legislatures will be willing to pass proper legislation and put the fire marshal in the same position occupied by other state officers, i. e., upon the state pay roll and maintained out of the state revenues as other state officers.

Any fire marshal will tell you the worst handicap he has is that his office is supported by a tax upon insurance premiums, and that he would be at least one hundred per cent more efficient if he were in the same independent position occupied by other state officers.

In Illinois, for example, or Kansas, or Ohio, where we have had the office for some years—and most of the time it has been fairly efficient—the fire marshals will tell you that immediately upon a firebug being apprehended and placed upon his trial, his lawyer, if he knows his business, proceeds to try the insurance companies, and the State's attorney is kept so busy with this question he hasn't much time to try the firebug.

This situation is made possible by the fact that the fire marshal's office is supported by a direct tax upon the insurance companies, and the presumption based on that fact that they would not submit to the passage of a law of this kind or a tax of such a character unless it was their law and that they were more than ordinarily interested in its administration.

A tax of $40,000 or $50,000, in a great state like Colorado, imposed upon the insurance companies, is not so large that the companies need make much fuss about it, but it also is not so large as to cause any comment by the people of Colorado if paid out of state funds, when the source of support makes all the difference in the world in the efficiency of the office.

In this letter Mr. Ryon suggests something almost invariably overlooked: the fact that the psychology of the people is affected by taxing insurance premiums to support the fire marshal's office. Such a procedure rivets in their minds still further the notion that fire prevention is fire insurance. They will not respond to their fire marshal's appeals because they consider him a spokesman for a special business interest. So they continue to pay the fire waste, and indirectly the cost of their fire marshal's office, and do nothing intelligent to reduce the cost of either. As Mr. Ryon suggests, when the people create and maintain the fire marshal's office as their own, they will co-operate with it, and make it effective—and reduce the fire waste.

The Boston Sprinkler Situation.

Shortly after the Melvin apartment house fire in 1914, when eight lives were lost in an unsprinklered wooden tenement building, the Massachusetts State Legislature passed an amendment to the Metropolitan District building code, providing that public halls, stairs, shafts and basements of all tenement houses more than three stories in height and having more than eight suites should be provided with automatic sprinklers. Because of opposition on the part of property owners and consequent litigation, the law was not enforced. Later, as a compromise measure, the original act was amended to apply only to non fire-resistive buildings four stories or more in height and housing ten or more families. But because of continued opposition the law was still not enforced.

In the fall of 1920, just at the time when the housing shortage was particularly acute, the mayor of Boston announced his intention of having the law enforced. After serving the legal notice on landlords, who neglected to comply with the law and install sprinklers, enforcement was begun in a few test cases. The law provides a $500 fine for the delinquent property owner. But no fines were imposed and instead, in accordance with another provision of the law, some hundred families were served with summary eviction notices. Some thousand others would have also been evicted if enforcement had been carried through along these lines. But injunctions were again invoked to give relief to the families who would have been able to find no other places to live.

As was entirely to be expected, the landlords complained bitterly against the sprinkler requirements which involved what they claimed was an unjustifiable expense, and refused to listen to any arguments on behalf of safety to life. It has been editorially stated that they have been encouraged in their opposition to the law by the attitude of the mayor, and implied that the mayor's enforcement methods were calculated, by their severity, to bring the law into disrepute and lead to its eventual repeal.

According to an estimate by the mayor the cost of the required sprinkler equipments would amount to some $2,000 per building. $2,000 per building means carrying charges amounting to about $1 per family per month. And it is this expense which is responsible for all the opposition to the law, and the absolute disregard on the part of the landlords of the safety to life which the sprinkler protection would afford.

The landlords, working through tenants' associations, organized the opposition to the sprinkler law, and brought before the Massachusetts State Legislature a bill providing for suspension of the law until March 1st. It is predicted that this action has in view the eventual repeal of the entire sprinkler requirement. In spite of the efforts of Secretary Wentworth and Mr. Alfred Davenport (member N. F. P. A.), in appearing at the hearing on the bill before the Committee on Metropolitan Affairs, the suspending bill passed the House on December 17th. On the date of

this writing, December 22nd, revising its vote of the previous day, the State Senate has adopted the bill, with amendments added by the Senate and concurred in by the House, providing that the suspension of the sprinkler requirement must be approved by the Mayor and the City Council of Boston before going into effect. Secretary Wentworth is making an appeal to Governor Coolidge to withhold his signature from the bill when it comes to him, but at the present time it is difficult to predict what the final outcome of the sprinkler controversy may be.

The Conflagration.

O burning fire,
Streaking the midnight,
Parching the silence.

O the flames that are arrows,
Shaken in a golden quiver,
The flames. . . .

O the flames that are sudden ripples
In an imprisoned river,
The flames. . . .

O the flames that are screaming children
Danced in a slippery lap . . .
The flames. . . .

O the wide-striding shadow of the flames,
The dark and stately smoke
That needs heaven
For a floor to die upon.

O burning Fire,
Tearing the face of the midnight,
Hissing into the ear of silence.

O red mouth
And yellow teeth
Of Fire.

I have seen you eat up trees and houses,
And fatten
Till your obese shadow covered the sky.

—Isidor Schneider.

Interruptions to Public Water Supplies.

By C. F. U. A., Montreal.
(Member N. F. P. A.)

In the good book—of Sprinkler Regulations—under the caption of Water Supplies, it relates that "for a standard equipment two independent supplies are required. Critics of this rule contend that where the only supply is from public water of normally good volume and pressure, the sprinkler equipment should be rated as standard, and to such unbelievers this attempt to prove the wisdom of the rule is addressed.

The single supply equipment has a legitimate and a wide field, but is not the equal of one with two entirely independent water supplies, designated as "standard" in the Sprinkler Regulations. It is doubted if it is generally recognized how often a public supply may be interrupted.

The saying that there are "white lies, black lies and *statistics*," it is felt, applies to other kinds of statistics than outlined in this article; for instance, income tax statement, or the alluring prospectus of some other doubtful investment.

Some years ago, the writer was requested to furnish details of very serious impairments to waterworks systems in the Canadian field, and since then has filed in a separate folder such happenings as came to his notice, hence this doleful tale. Without "hunting for trouble," there does not appear to be any difficulty in compiling annually a long list of failures or interruptions of varying magnitude, and not confined to any one country or section, although naturally those nearest to the writer's own field total the greatest number, not necessarily because conditions are worse, but the more readily brought to notice. The data compiled is from the printed lists of the Factory Mutuals, the journals of the American and New England Waterworks Associations, the records of the various Canadian Underwriters' organizations, N. F. P. A. literature, and a few newspaper clippings. To publish in detail would preclude to other aspiring authors or budding geniuses the use of the pages of several volumes of the QUARTERLY. Let any doubting Thomas start a file of his own.

Interruptions to public water supplies are many and varied. Man and the elements, jointly and severally, are responsible. Fire and frost, drought and flood, weakness and strength (of material) all contribute. The casualties may be divided into two general classes: major, where there is a very serious failure or interruption, and likely to be brought to the public notice; and minor, where only a small section is affected for a brief time, and not generally known.

The lists embrace nearly one hundred municipalities in the States and half that number in Canada, not including those later mentioned under interruption to electric power, and range from the small town to the largest city, with many repetitions in some localities. The major casualties include breaking, or choking with foreign material, of large conduits; breakdowns or repairs to pumps; breaks from a variety of causes, or

severe leaks, in large feed and supply mains; foreign material in pumps or mains; collapse of tanks and standpipes; failures due to floods, fires, ice, wind, breaking of dams or reservoirs; interruption of electric circuits; labor disturbances; throttling of valves in main feeders; reductions in pressure due to large fires or other heavy draught in the neighorhood. In period of time they range from a few hours to many days.

Among the minor casualties are the temporary shutting down of short sections of supply mains, due to breaks or leaks from various causes, including electrolysis; or for repairs or changes to mains, valves, hydrants or service connections; cleaning of mains; pitometer surveys to detect leaks. It is reported that four hundred hydrants are annually damaged by automotive apparatus in one very large city and three hundred annually in another.

Large losses from fire have not been escaped during these interruptions. In Canada, a loss of over $430,000 on several sprinklered properties was directly due to a breakdown of the waterworks system coincident with the start of the fire; and another loss approximately 40 per cent. of the first is attributed largely to the throttling of the waterworks supply in the vicinity of the sprinklered property and the failure to open the necessary valves until too late. The argument is not weakened by the fact that in each of these cases there was a secondary supply, not of value under the circumstances surrounding the fire. Losses are noted in the lists from the States, but the writer is not familiar with the details.

It has also been impressed upon the writer what trivial causes may temporarily deprive a large number of sprinklered properties, where closely grouped, of their public water supply, at least from one connection. Repacking of a street valve or repairs to a small domestic service connection, or repairs to a hydrant, our records show, have interrupted the public water supply from at least one city connection to a number of equipments. One illustration will suffice: To repack a waterworks valve, thirteen street valves were shut, cutting off for one hour a twelve-inch street main for a distance of four blocks, or about 1,600 feet. Five sprinkler equipments were without automatic protection; six were dependent upon a second city connection from independent mains; five more were dependent upon tank supply; eight city hydrants were out of service.

Another accident, minor in itself, but with serious interruption to protection, might be noted. A break in a 10-inch main occurred at the top of a hill. As the sewer connections were stopped with snow and ice, the water covered a considerable area, and owing to the necessity for digging the snow and ice to uncover the street valves, it took some three hours before the flow of water could be stopped and the closing of twenty-two valves, shutting off temporarily all of the fire protection in an area about six blocks square. Approximately thirty hydrants were out of service, also one sprinkler equipment entirely, and two others were dependent upon tank supply. As an item of interest, when the broken main was uncovered it was found that the frost had penetrated the ground 3 feet 9 inches before the middle of February. The street is paved with scoria blocks on a concrete bed, total thickness eighteen inches, and there was a further covering of approximately eighteen inches of snow and ice. The main was buried some 6 feet 9 inches from the top of the pipe to the street level. Another unusual occurrence is that of eels being drawn into

the turbine pumps, which has closed down temporarily on several occasions the pumping plant of a small town and deprived it of its hydrant protection and also the sprinkler equipment of water supply in a number of properties.

There is always danger, when a number of street valves are closed, that some will be overlooked in the reopening; in fact, water flowing tests at inspections have disclosed this on several occasions. See also the QUARTERLY for April, 1913, "Waterworks Systems and the Fire Protection Problem," by Clarence Goldsmith.

Interruptions to electric circuits have entirely shut down the direct pumping plants of two cities of considerably over 100,000 population (one nearly 200,000), thus temporarily depriving them of water. In one case, the interruption was very short, the old hydraulic plant, kept in reserve, being immediately started up. In the other case, the water was off for a total of ten hours on two successive days, due to delay in starting the old steam plant.

In a severe storm, which swept over one of the provinces in November, 1919, the electric power to twenty-one municipalities on the same general system was interrupted for varying periods of a few minutes to three days; but only two of the towns did not have reserve in the shape of standpipes or steam or gasoline driven pumps. A number of the overhead transmission lines run many miles, and the value of a reserve or standby to an electric pumping plant was very forcibly illustrated in this instance, as well as in the cases mentioned in the preceding paragraph.

A rather unusual result through another interruption to an electric circuit, a little aside from the scope of this article, was its effect on fuel oil fired boilers equipped with electric motor pumping apparatus. The failure of the electric power shut down the boilers from one to five hours, and in two sprinklered properties the temperature dropped so low that it was necessary to shut off and drain the sprinkler equipments to prevent freezing. In several other sprinklered properties the temperature in the building remained sufficiently high to avoid this, or there was a reserve heating apparatus which was temporarily placed in service.

The collecting of data on this topic must from its very nature be more or less "dry," in keeping with the times, but is not without its humorous side. One short circuit on a high voltage line was due to a tomcat, who, it is recorded, lost his nine lives at once thereby. A newspaper heading, "Fearful Plight of Villagers," referred to a place in Switzerland where the inhabitants were faced "with the prospect of being able to drink *only wine and beer* for some time, the result of the town waterworks being washed away by flood." Many weeks were estimated as necessary to restore the waterworks system. From inquiries that have come to the writer regarding conditions in his home town, from points further south, it can be conceived that even some staunch N. F. P. A. members might view as not an altogether unmixed evil, some such calamity as indicated to their own municipality.

Water Starts a Fire.

By John S. Caldwell.

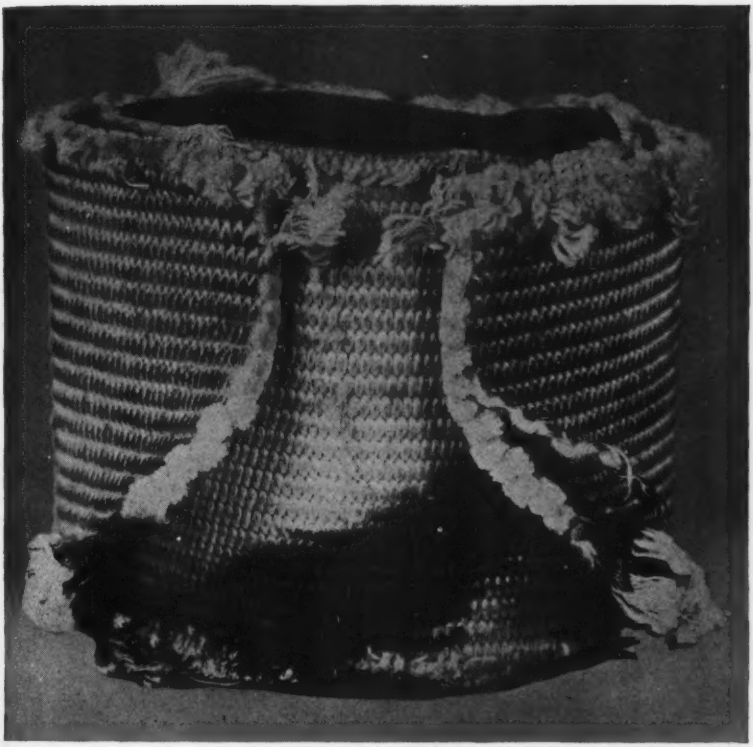
(Member N. F. P. A.)

A startling news item with the above caption, which appeared recently in the daily press, has created widespread interest throughout the country, and it will doubtless be interesting for National Fire Protection Association members to know the circumstances surrounding this so-called phenomenon.

The first occurrence happened during the operation of a motor pumping engine in the Boston Fire Department, resulting in the burning of a hole in the cotton jacket of the hose about the size of a half dollar at a point near the coupling where attached to the pump. Shortly following this, the writer had the opportunity of duplicating this condition, and since then has conducted two tests under similar conditions with practically the same results.

The following is the condition under which the burning occurred. A single line of 2½-inch double jacket cotton rubber-lined hose, to which was attached a deluge set with a 1¾-inch outlet, was connected to a 750-gallon automobile pumping engine equipped with a rotary pump. The pump was operated so as to maintain 250 pounds water pressure on the discharge gage by throttling the gate on the pump so that an opening of only ⅜ to ½ inch was obtained, and discharging only a comparatively small amount of water, from 250 to 300 gallons per minute, at a very low pressure at the nozzle. The throttling of the discharge gate produced a stream of very high velocity, the direction of which was at an angle with the discharge outlet, due to the valve opening being at the side. This high velocity jet, so to speak, impinging against the side of the hose near the coupling where connected to the pump discharge outlet, caused a slight deflection or distortion of the hose at the point of impact, and resulted in excessive vibration or fluttering of the hose, together with a slight indentation or kink on the under side, due to an insufficient volume being discharged to properly stiffen the hose line. After a period of two to three minutes, the hose commenced to get perceptibly warm on the under side near the coupling. In about two minutes more the cotton jacket became so warm that the hand could not be retained against it. The next indication was the distinct odor of hot rubber, followed by smoking and gradually by a discoloration of the outer jacket as the cotton fibres were carbonized; the fibres then commenced to fray and part, and as the outer jacket let go, it was observed that the inner jacket was carbonized in the same manner, followed quickly by the bursting of the hose at this point, due to the lack of support for the rubber lining. The total time consumed in bringing about this condition was approximately fifteen minutes.

Following this, a test was made under similar conditions, except that a centrifugal type of pump was used, and in this case, in order to produce the condition, a hose gate was attached to the pump outlet, due to the fact



Full size photograph of a section of hose used in the third test referred to in this article. The outer jacket has been cut and opened to show the charring on the outside of the inner jacket and the inside of the outer jacket, caused by friction between the two jackets when water was being pumped through the hose under the peculiar conditions explained in the text.

that the regular pump discharge valve was not in proper relation to the hose to produce the desired result. The same fluttering and heating of the hose was noted as in the first test, but before sufficient heat was generated to carbonize the cotton jacket the lining burst, thus allowing the water to cool off the hose; but unquestionably, if the lining had not ruptured, the same results as in test number one would have been obtained.

The third test was made utilizing the piston type of pump under similar conditions, and a duplicate of test one was obtained, except that the test was stopped before the hose burst so as to observe the full effect of the burning. In the first and third tests an examination of the hose showed the most charring of the cotton to be at a point between the inner and outer jacket where the kink in the line occurred.

From the above the following conclusions are drawn:

(1) That the type of pump utilized, that is, rotary, centrifugal or piston, has no bearing on the case.

(2) That the make of the hose used is not a factor, as three well-known brands of hose were utilized.

(3) That, in order to produce the condition, certain features must be considered: such as size of outlet, to create a wide differential between pressures on pump side of throttle gate and hose side; and also the relation of the gate in connection with the distance to the hose, in order to get the full effect of the high velocity jet.

(4) That the cause is friction between the inner and outer jackets of the hose induced by the high velocity stream, thereby causing the vibration or fluttering of hose at a point near the coupling where the kink in the line occurs.

(5) That the possibility of burning hose, while interesting because of its peculiar nature, is a matter which does not warrant any change in the design of either pumping equipment or hose, as the conditions under which it is produced would never be encountered in practical fire department work.

The Fire Warden.

By Muriel Harris.

(An English writer's impressions reprinted from the *Manchester Guardian*, Manchester, England.)

The fire warden, who watches for forest fires, spends his summers on the summit of Mount Hurricane, which is in Essex County, which is in the triangular State of New York, which is so big that you can travel whole days within its boundaries. At one end of it big British liners land travellers to America. At the other are Niagara and Canada. Somewhere between the two the fire warden thrones in his thirty-foot tower on the top of Mount Hurricane. As regards height, Mount Hurricane has nothing much to boast of, being only some three to four thousand feet. Considering the bigness of things generally in America —the immense rivers and lakes and waterfalls and country—it is a pigmy among mountains. You climb it as an initiation into mountaineering. It will give the raw city man stiff backs to his legs for a day or two. It will take his breath and make him hot. In the winter it can boast of a dozen feet of snow. But it is little more than a good walk, some twelve miles or more up and down, up which the fire warden carries his food, his bedding, his books with which to lighten his lonely vigil.

The trail to the fire warden's tower is half obliterated and there are no trees to show the blazing. Seven years ago the whole mountain caught fire. The roar of the fire could be heard for miles. Masses of lumber stacked on the mountain side were caught in the furnace. The white birches burned like tinder. Great spruces became a blackened ruin. The fire spread over the valley and up the other side, and the Lost Pond, to

find which had long been a game for travellers, was suddenly discovered from its tangled hiding-place and laid bare to every eye. Today there has grown up a thicket of small wood, at first a wilderness of wild raspberries, then a soft undergrowth of birch, spreading like a green blush over the mountain side. The trail is becoming today a sort of alley, close and green and shutting out the view. Now and again in the thicket you can see the charred remains of the lumbermen's huts. Bridges of spruce are precarious walking, to be crossed with care. And from amidst the soft green thicket rises an army of bleached tree trunks, burnt off short ten or twelve feet up and standing like gravestones in No Man's Land.

In the clear September sunshine, with a sharp nip in the air to brace your walk, the climb up Hurricane is perhaps one of the most delicious things of the world. There is still primeval forest at the foot, the great trees towering overhead, some of them snapped at the base with age and lying ponderously across the trail. So they were when the Indians were sole denizens of the woods. So they have been for no one knows how many hundreds of years. At the top the bare volcanic rock shows itself, with small tufts of beech growing in the cracks. The rock is rough and easily accessible. It has rained recently, and small pools lie in the hollows. Across the valley lies the Lost Pond, unveiled. And then there is a view 20 miles in all directions, range after range of soft, blue mountain, towards beautiful White Face, towards towering Marcy and Indian Head, towards the great waters of Lake Champlain, lying like a map below; across them to the Green Mountains of Vermont, and, straight ahead towards Giant and Noon Mark and the lesser fry, Pichoff and Tripod. And then there is the fire warden's tower.

The fire warden is a highly civilized young man. He knows a good deal of book knowledge as well as woodcraft. And yet there is something natural, even primeval, about him too. He lives among the mountains, guards them, watches them. There is a ruggedness in his brown face which savours of them. There is a distance in his searching eye which suggests them. He speaks softly and slowly, with a gentle, country accent. He likes a chat, even depends on it a little, but there is no welcoming haste about him. It is all in the day's work. His fathers settled here; they fought man and nature, and he is guarding the inheritance. The fire warden is one of the contrasts, upon which one is always stumbling in this country, between the crudely new, the desire for some new thing, and the primeval of the forest and the great volcanic mountains.

A Difficult Lumber Yard Fire, Finch Lumber Yards, Brooklyn, N. Y. This phot graph illustrates the difficulty experienced by firemen in fighting fire in lumber piles. The uneven piling of the lumber makes effective attack possible from only one direction, the end of the pile, as shown in the picture.

Corrosive Action and Products Formed when Carbon Tetrachloride Extinguisher Liquids are Applied to Fires.

By A. H. Nuckolls,

(Chemical Engineer, Underwriters' Laboratories. Member N. F. P. A.)

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Introductory.

Carbon tetrachloride extinguisher liquid is essentially a mixture of carbon tetrachloride and ingredients for depressing the freezing point. Underwriters' Laboratories' Standard Specifications for the class require that the admixture shall be practically free from objectionable impurities such as water or other substances that cause corrosion, act as toxics or materially reduce the extinguishing efficiency.

The fumes resulting from the application of carbon tetrachloride liquids to a fire are acid in character and irritating to the lining of the respiratory passages.* In many buildings and workrooms the materials or products handled are of such a nature that carbon tetrachloride extinguisher liquid is the only agent well adapted for use in extinguishing fires therein. If serious corrosion of fine tools, dies, etc., by the fumes should occur it would result in considerable loss.

Further, the use of carbon tetrachloride extinguisher liquid may result in the exposure of employees or others to the fumes. At the request of the National Board of Fire Underwriters and the National Fire Protection Association, the present investigation was undertaken to obtain information of practical bearing on these problems, including the nature of the fumes resulting from contact of tetrachloride liquids with fire, the corrosive action on metals, and the toxic compounds produced.

Plan of Investigation.

To determine the corrosive action and nature of the fumes resulting from application of carbon tetrachloride extinguisher liquid to fires, a series of actual tests extending over a period of several months were conducted. In these tests streams of the fluid were applied to the burning materials in an enclosure of a size comparable to that of an ordinary small room, in which metal specimens were exposed and from which samples of the fumes were withdrawn for chemical analysis. It was sought to have the experimental conditions such that the production of corrosive and irritating fumes would be much greater in these tests than under the conditions usually met with in practice.

*NOTE: Attention is called to the irritating character of fumes or gaseous products of combustion from ordinary fires when water is used as the extinguishing liquid, including carbon dioxide, monoxide, acrolein, pyroligneous acid (wood), sulphur compounds, etc.

in fighting fire in lumber piles. The uneven piling of the lumber makes effective attack possible from only one direction, the end of the pile, as shown in the picture.

The extinguishing liquids employed in the tests included: pure carbon tetrachloride, mixtures of tetrachloride with common ingredients used for depressing the freezing point, and mixtures taken from cans filled for the market by manufacturers of these products under the Laboratories' Standard Specifications for Liquids for Use in One-Quart Extinguishers. Various products made up to other specifications which might be obtained on the open market were not included. Accordingly the results of the tests and conclusions based thereon necessarily apply only to standard fire extinguisher liquids of the class* indicated.

The method or procedure used for application of the extinguishing liquids to the test fires was designed to give finer streams or more spray than the method usually employed by one in extinguishing a fire in practice. It was thought that the fine spray, while perhaps less efficient in extinguishing fires, would give an increased production of fumes or decomposition products.

Fires in the open (no enclosure) would evidently present unfavorable conditions for the action of corrosive and irritating fumes, owing to dilution by the air. In an enclosure a higher concentration of the fumes would occur. A moderate sized enclosure which would present conditions comparable to those met with in practice, where these liquids are commonly used to extinguish incipient and small fires in workrooms, shops, etc., appeared to be the best adapted for the tests.

The ventilation of the enclosure for the test fires presented a problem that was given careful consideration. An over supply of air to the test fire would not be favorable to the formation of fumes and subsequent analysis, while too small a supply of air would result in combustion too weak to give a satisfactory test. It was accordingly decided to regulate the supply of air by means of openings in the furnace so as to produce test fires of an intensity comparable to those which occur in practice in small rooms, shops, open closets, etc.

The test fires included three principal types: burning gasoline, alcohol and wood. A few tests were also made with turpentine and roofing material (tar, asphalt, paper, etc.). The plan was first to conduct tests with the three principal substances mentioned, which are representative of a large number of fires met with in the field, and to note variations or differences between the products from each and determine whether the three types selected were adequate for the purpose, or whether additional kinds of fires would be required.

A few supplementary tests were also made with gasoline and alcohol flames in a small box.

Examination and Test Record.

Apparatus and Equipment.

ENCLOSURE OR FURNACE FOR TEST FIRES. The test fires were conducted in a brick furnace of rectangular shape, 4 feet wide, 6 feet long and 9 feet high. Thirty-six air inlet openings, 2 by 3 inches in cross

*NOTE: It has come to our attention that experimenters not familiar with the hazards involved have, by adding ingredients to carbon tetrachloride, perhaps to increase the extinguishing action or lower the freezing point, produced mixtures which when applied to fires might become a menace to life. As indicated in the text, such mixtures are not within the scope of the present investigation.

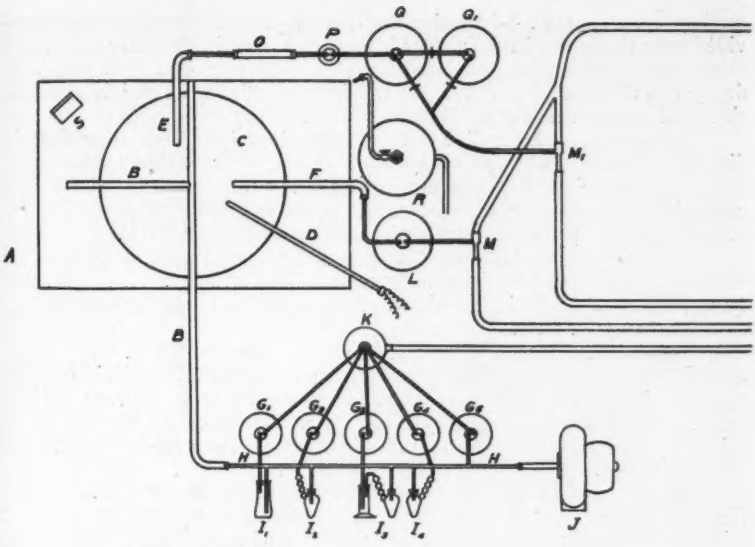


FIG. 1

A. Furnace.
B. Asbestos wrapped sampling tube.
C. Cylindrical tank for liquid fuel.
D. Thermo-couple.
E. Porcelain sampling tube for the phosgene determination by aniline.
F. Porcelain sampling tube for dry sample.
G_1, G_2, G_3, G_4. Two liter aspirator bottles whereby the gas samples are drawn by suction through the various reagents. G_5 is a 2 liter bottle for the collection of a gas sample over water. (2 liters=2.11 qts.).
H. Header.
I_1. Contains potassium iodide solution for the detection and estimation of chlorine.
I_2. Contains distilled water, and mercury, for the collection of hydrogen chloride.
I_3. Apparatus used in an unsuccessful attempt to condense carbon tetrachloride and phosgene vapors, the two tubes being submerged in freezing mixtures.
I_4. Contains ammonia solution for the phosgene test.
J. Motor-driven fan whereby the products were drawn into the sampling tube and through the header.
K. Receptacle for water from the various bottles. It is connected to a drain.
L. 18 liter (.635 cu. ft.) bottle for the collection of a sample of fumes without contact with water.
M and M_1. Represent water pumps, supplying suction.
O. Glass tube containing glass-wool and metallic antimony.
P. Flask containing aniline solution for absorption of phosgene.
Q. Aspirator bottles (18 liter each) for withdrawing and measuring volume of sample for phosgene determination.
R. The pressure-tank for extinguishing liquid, with nozzle.
S. Is a rack of three wooden shelves wherein corrosion samples were placed.

section, eight on each 4-foot side and ten on each 6-foot side, were provided near the base of the furnace. A stack 1 foot in diameter connected the furnace with an outside flue. The draft was regulated by means of a damper in the stack. Observation windows of mica were provided in the side walls and corners at convenient heights.

For alcohol and gasoline fires a galvanized iron tank four feet in diameter by one foot high was placed on the floor of the furnace and used as a container for the burning liquid. A removable 2-inch pipe extending from an observation window in the furnace wall to the bottom of the tank was provided for pouring the liquid into the tank.

SHELVES FOR METAL SPECIMENS FOR CORROSION TESTS. A rack of wood for the exposure of the specimens to the fumes was built, having three shelves about 16 inches apart. The rack was set up in a corner of the furnace (Fig. 1-2).

APPARATUS FOR OBTAINING SAMPLES OF GAS FOR TEST. For withdrawing samples of gas from the furnace for chemical analysis an iron pipe was installed so that it extended from the front to the rear wall of the furnace, one end being capped and set in the wall. At the middle of this pipe, and perpendicular to it, was fitted a ½-inch 4-foot iron pipe with open end. Both pipes were carefully wrapped with sheet asbestos so that contact of reacting vapors with metal might be avoided. Before the start of each test fire, the pipe was clamped in an upright position, with its open end about 1½ feet from the top of the furnace. The gases were drawn from the interior of the furnace through this sampling tube into the header of the gas sampling apparatus by means of suction developed by a motor-driven blower. The rate of flow of gases was regulated by a valve in the line between the header of the gas testing apparatus and the blower.

Five water-aspirator bottles were attached to the header referred to above, each containing a measured volume of water so that the escape of this volume of water would show that a like volume of gas had been collected. The aspirators were connected as follows:

(1) To an absorption tube containing potassium iodide, for the detection of chlorine.

(2) To an absorption tube containing pure water, together with a little mercury to collect hydrogen chloride.

(3) To two tubes in freezing mixtures to condense carbon tetrachloride and phosgene.

(4) To an absorption tube containing ammonium hydroxide for the absorption of phosgene.

(5) A water-filled bottle for the collection of a sample of the gas for examination for oxygen, carbon dioxide and carbon monoxide.

By adjusting the discharge outlets of the aspirators so that all the bottles emptied in about the same time interval, a fairly uniform sampling of the gas along the header was accomplished.

In addition to the iron pipe for withdrawing samples of gas as described above, a porcelain tube ½ inch in diameter and 3 feet in length was provided for the purpose of collecting relatively large volumes of gas to enable the determination of small percentages of phosgene by a method worked out by experiments. The tube was introduced through a hole in the back wall of the furnace. The outer end of this tube was connected

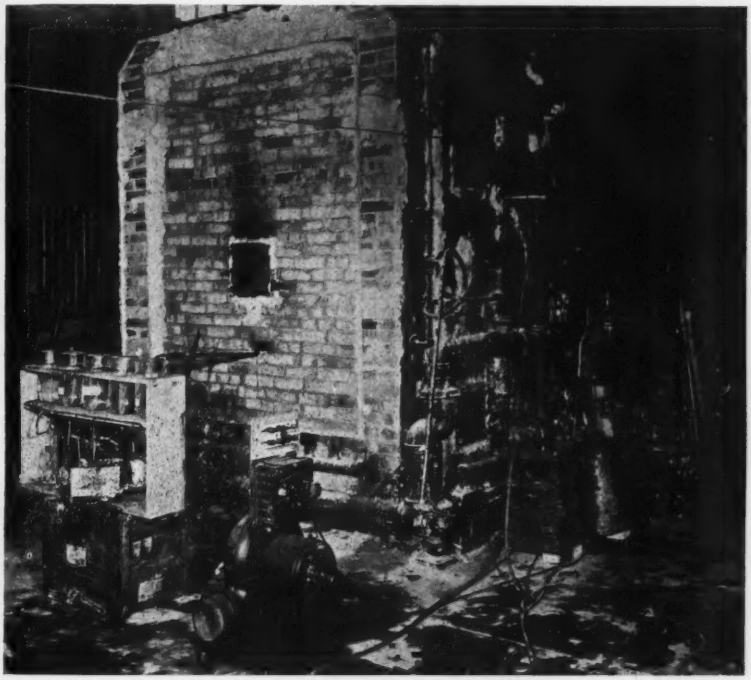


Fig. 2. The furnace and apparatus.

with a ¾-inch glass tube about 12 inches long filled with glass wool and finely granulated antimony, for the purpose of arresting any free chlorine that might be present in the fumes, and also any solid matter. The antimony tube was connected with an absorption wash bottle containing about 250 c. c. of a clear, fresh saturated aqueous solution of aniline. From the wash bottle, a tube led to an arrangement of two large (18 liter) bottles filled with water, so fitted as to serve as aspirators, the volume of water discharged from the bottles represented the volume of vapors drawn through the aniline solution.

Further, a porcelain tube was provided in a side wall of the furnace so that an 18 liter sample of gas could be taken by displacement of air without contact with water. Suction was provided by means of a water-pump.

TEMPERATURE. A platinum-rhodium thermo-couple with hot junction 3 inches above burning liquid was employed for observation of the relative temperature.

FURTHER DETAILS OF APPARATUS. The sketch (Fig. 1) of the furnace and sampling equipment is diagramatic, no attempt having been made to preserve the proportions of the various parts of the apparatus. Reference to the photograph (Fig. 2) and to the text descriptive of the equipment will give a correct idea of relative sizes.

Methods of Test.

TEST FIRES (PROCEDURE). In the case of liquids, about two gallons were poured into the iron tank in the furnace and ignition accomplished by means of a torch.

For wood-fires, the procedure was as follows: Upon two brick piers were placed angle irons in such a way as to make a foundation one foot from the floor, upon which was erected a pile of wood made up of 78 pieces of 2 by 2 inch, air-dried, rough-sawed yellow pine, two feet long. These pieces were laid in tiers in such a way as to make a pile in the general form of a 2-foot cube, half of the total volume being occupied by wood and the other half by air (space). A sheet-metal pen containing one part of gasoline was placed directly under the center of the pile and lighted.

The extinguishing agent was placed in a steel tank connected with a compressed air supply, and applied to the fire by means of an air pressure of 20-40 lbs. per square inch through a spray nozzle which projected into the furnace through an observation port. The spray was so regulated by a valve that the quantity of liquid delivered to the fire could be increased or decreased as the intensity of the fire varied, the object being not to extinguish the fire in the shortest possible time, but to secure such intimate contact between fire and extinguishing agent as to give maximum opportunity for the formation of reaction products.

TEST FOR CORROSION OF METALS. In each test fire specimens of steel were exposed to the fumes. The specimens included:

(*a*) Ever-Ready Safety Razor Blades.
(*b*) Gillette Safety Razor Blades.
(*c*) Steel blades used for carpenters' planes.

One specimen of each kind of steel was laid upon each of the shelves, except the middle shelf, upon which two specimens of each kind were placed. At the conclusion of a fire test, the furnace was left unopened for twenty-four hours, at the end of which time it was opened and the specimens removed and examined visually. After examination, the specimens were studied in order that as much as possible might be learned regarding their corrosion. The following procedure was carried out:

(1) Specimens were placed in envelopes and the envelopes in turn placed in a desiccator, from which they were removed from time to time for examination of the steel.

(2) Others were placed similarly, removed after two weeks, cleaned by rubbing lightly with a cloth saturated with ether, and examined.

(3) Others were cleaned, as in (2) above, immediately after removal from the furnace, and then placed in the desiccator, as in (1), for subsequent examination.

Specimens from Alcohol Fire No. 1, Gasoline Nos. 1 and 2, and Wood Nos. 1 and 2 were photographed. Inasmuch as no difference in results was observed in subsequent fires, it was not considered necessary to photograph the specimens therefrom, especially since examination of fumes showed no significant difference in the products from the various fires.

ANALYSIS OF GAS. Samples of fumes were taken for the purpose of:

(1) General gas analysis, including determinations of oxygen, car-

bon dioxide and carbon monoxide, qualitative test for chlorine, qualitative test for phosgene, and quantitative test for hydrogen chloride.

(2) For quantitative estimation of phosgene.

(3) A representative sample of the fume collected by aspiration of air, without the use of water.

The diagramatic plan (Fig. 1) shows all arrangements for sampling in detail. This should be examined in connection with Fig. 2, which shows a perspective view of the equipment.

Examination of the fumes included quantitative analysis for:

1. Oxygen.
2. Carbon dioxide.
3. Carbon monoxide.
4. Hydrogen chloride.
5. Phosgene.

and qualitative tests for the presence of:

6. Chlorine.
7. Sulphur dioxide (in some cases).
8. Higher chlorides of carbon (in some cases).

Oxygen, carbon dioxide and carbon monoxide were determined by the ordinary Orsat method. In this connection it should be noted that: where not removed by solution in water, the percentage of carbon dioxide includes any carbon dioxide, hydrochloric acid, phosgene and chlorine that might be present. The quantities of the latter four substances were, however, of such a low order of magnitude as not to affect the Orsat determination materially. It also should be borne in mind that the determination of carbon monoxide, where 0.0% is recorded, is the Orsat determination, and that this means that there is less than 0.1% of carbon monoxide present. No examination for minute quantities of carbon monoxide was carried on, as it was not thought necessary in view of the fact that ordinary smoke contains small quantities of that gas.

Hydrogen chloride was determined by aspirating a known volume of fumes through water in contact with metallic mercury (to absorb any possible chlorine), and titrating the acidity of the water with standard alkali solution, methyl orange being used as indicator. Hydrogen chloride was also determined by titrating portions of the solution formed by shaking the contents of the large sample bottle with water.

Examination for chlorine was made as follows: Known volumes of the fumes were drawn through aqueous potassium iodide solution, with the intent to titrate the liberated iodine with sodium thiosulphate solution.

Two independent methods were used for phosgene: one qualitative and the other quantitative.

For qualitative test, about two liters of gas were aspirated through ammonia solution in an absorption tube. The resulting solution of urea (formed by reaction between phosgene and ammonia) and ammonium chloride was evaporated to dryness, extracted with amyl alcohol, in which ammonium chloride is insoluble, and treated with saturated amyl alcohol solution of oxalic acid. Phosgene, if present, gives a fine crystalline precipitate of urea oxalate.

For quantitative test, volumes of fumes of about 20-30 liters were drawn from the furnace through a column about 12 inches long of finely granular metallic antimony and glass wool to remove any chlorine, and

then into cold, fresh, saturated aniline solution. Aniline reacts quantitatively with phosgene, giving diphenyl urea, which is insoluble under the conditions, and which may be separated from the solution by filtration, purified by washing, dried and weighed.

Chlorine was sought through examination of the antimony in the tube used in the phosgene determination.

Tetrachlor benzol was sought in the soot deposited on the walls and flues of the furnace by some of the fires as follows: The soot was collected, extracted with benzol, the mixture filtered, the solution evaporated to dryness on a large watch glass, and the residue heated gently on the sand bath with an inverted funnel over it.

In several instances tests were made for sulphur products by oxidizing the residues from the ammoniacal solutions after extraction with amyl alcohol in the phosgene tests, with nitric acid, diluting with water, and adding barium chloride whereby sulphur was detected as barium sulphate. The characteristic odor of sulphur dioxide was also sought in the fumes from the fires where carbon disulphide was employed in the extinguishing liquid.

Results of Tests.

Corrosion.

GENERAL. All specimens showed evidence of having been attacked by the fumes. A deposit of soot was formed upon the surface of the metal specimens, particularly in the case of wood and gasoline fires. The deposit was adherent and contained an oily-like substance, which acted as a sort of binder. This appeared to be carbon tetrachloride or other chloride. Specimens which were wiped clean immediately after the twenty-four hour exposure in the furnace, and subsequently kept in a desiccator, were not materially damaged, being much less corroded than specimens from the same fires which had received the same treatment except cleaning. In other words, contact of the deposit with the metal after the fire, even in the dry atmosphere of a desiccator, caused corrosion; in undried air this corrosion was more severe.* Test specimens were less corroded when exposed to the fumes of similar fires extinguished by the application of water from a soda and acid extinguisher.

The results in detail follow:

ALCOHOL FIRE.

Photograph No. 1:

Specimens 1, 2 and 3—Were new blades, photographed for comparison.

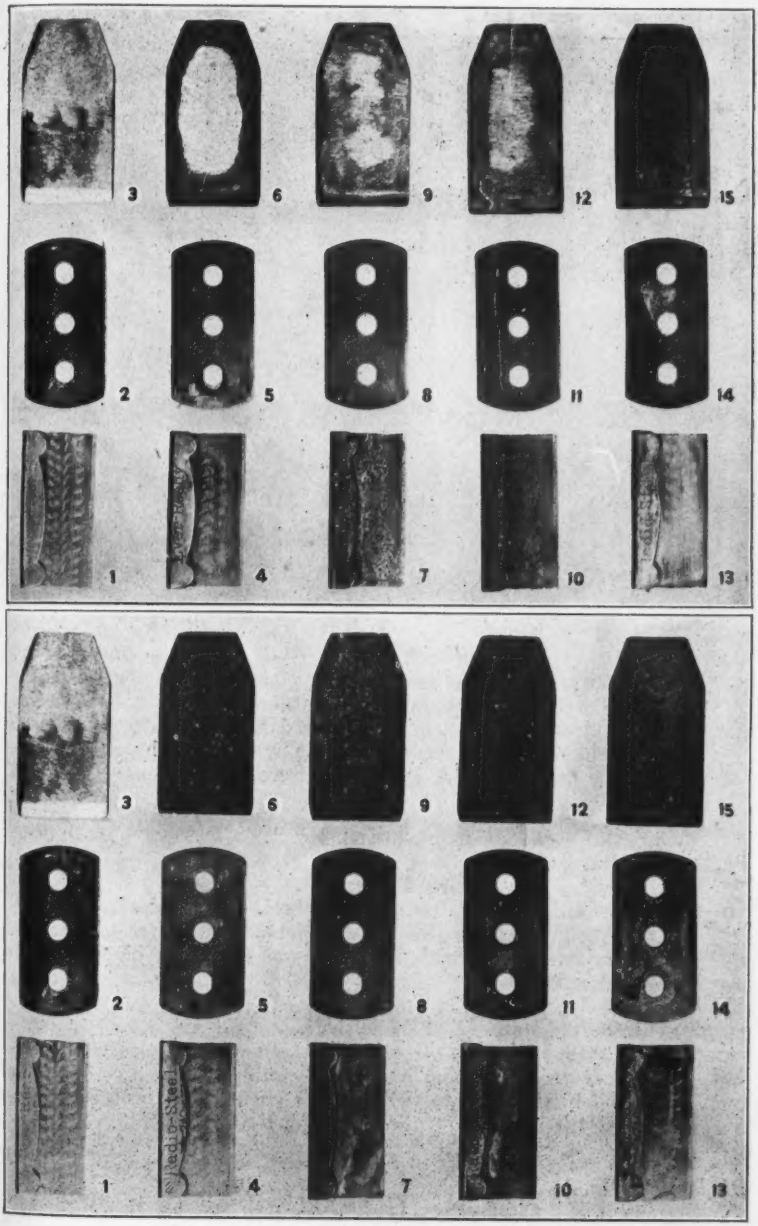
Specimens 4, 5 and 6—From middle shelf, which were cleaned immediately after removal from furnace, showed slight corrosion, as indicated in photograph.

Specimens 7, 8 and 9—From bottom shelf.

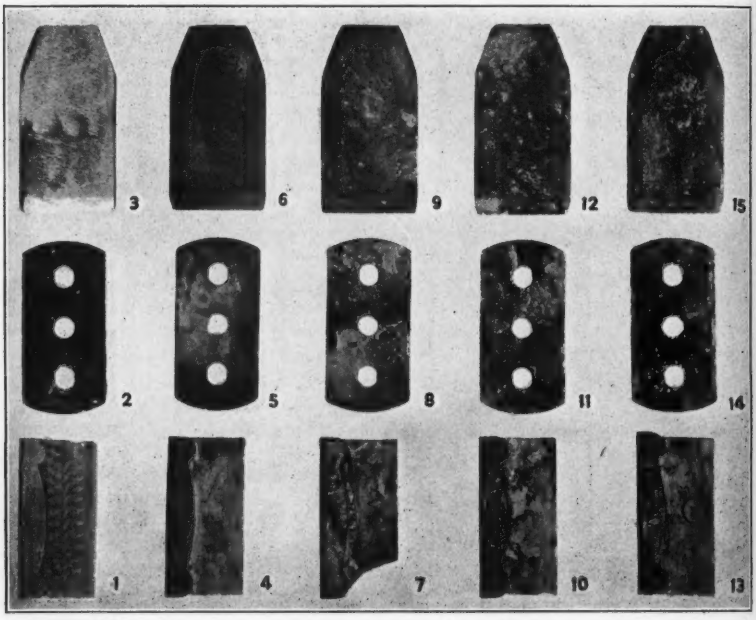
Specimens 10, 11 and 12—From middle shelf.

Specimens 13, 14 and 15—From top shelf.

*NOTE: It is to be noted in this connection that steel corrodes in moist air in the absence of other corrosive agents. What proportion of the corrosion observed was due specifically to the fumes was not determined.



Photographs No. 1 (above) and No. 2 (below)



Photograph No. 3.

Specimens 7 to 15 inclusive, which were placed at once in a desiccator after twenty-four hours in the furnace, and after two weeks, were cleaned and examined, showed a decided deposit due to corrosion, more in every case than was shown by 3, 4 and 5. Of the three sets, 13, 14 and 15 were more strongly corroded than the others.

GASOLINE FIRE NO. 1.

Photograph No. 2:

Specimens 1, 2 and 3—New Blades.

Specimens 4, 5 and 6—From middle shelf. Cleaned after twenty-four hours, kept in desiccator and examined after two weeks. No evidence of corrosion. No. 6 was somewhat blued by high temperature.

Specimens 7, 8 and 9—Bottom shelf.

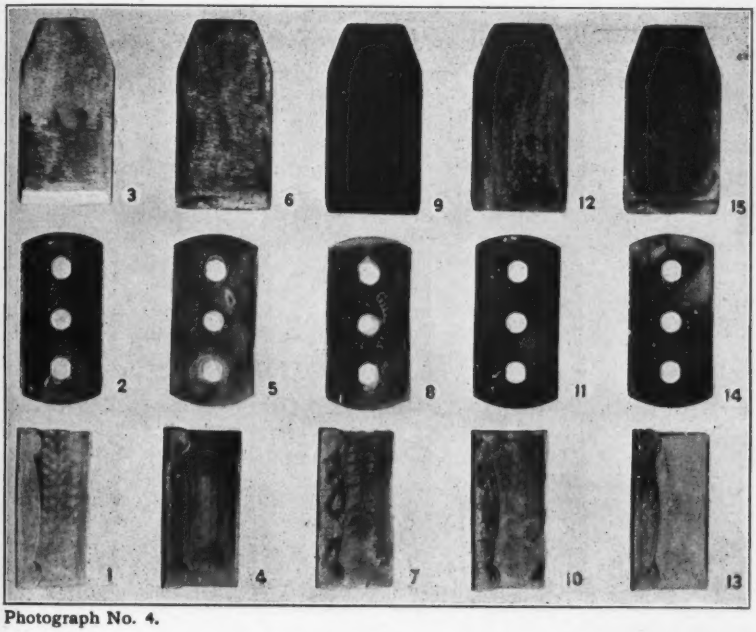
Specimens 10, 11 and 12—Middle shelf.

Specimens 13, 14 and 15—Top shelf, which were all placed in desiccator without cleaning immediately after the twenty-four hour period in the furnace, which were slightly but uniformly corroded, the last six slightly more than Nos. 7, 8 and 9.

WOOD FIRE NO. 1.

Photograph No. 3:

Specimens 1, 2 and 3—New blades.



Photograph No. 4.

Specimens 4, 5 and 6—From middle shelf; cleaned after twenty-four hours in furnace, kept in dessicator and examined after two weeks. Very slight evidence of corrosion.
Specimens 7, 8 and 9—From bottom shelf.
Specimens 10, 11 and 12—From middle shelf.
Specimens 13, 14 and 15—From top shelf, which were removed from furnace after twelve hours, held in desiccator for two weeks, cleaned and examined, were badly corroded. Nos. 10, 11 and 12 more than the others.

GASOLINE FIRE NO. 2.

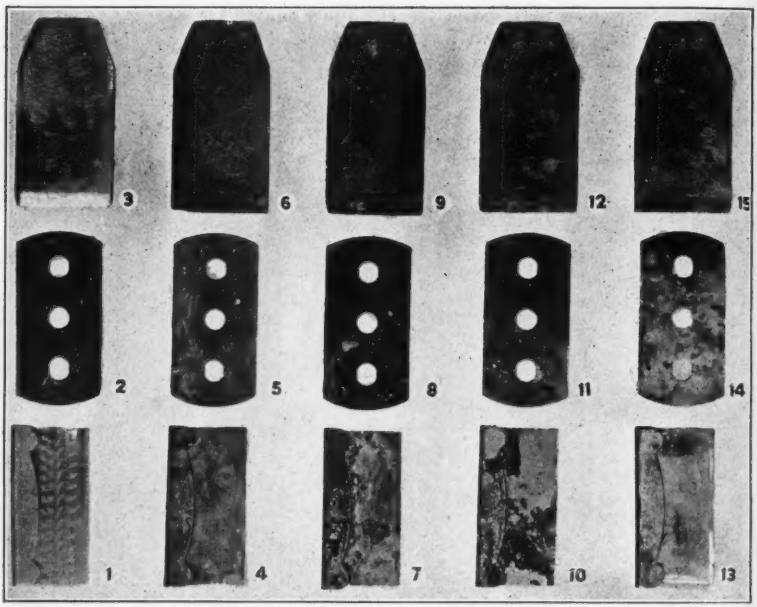
Photograph No. 4:

Specimens 4, 5 and 6—Practically free from corrosion. Others very slightly corroded—much less than in Gasoline Fire No. 1 or Wood No. 1. This is easily understood inasmuch as, due to difficulties with the extinguishing system, less than a pint of liquid was applied to the fire, and the resulting corrosive fumes (hydrogen chloride and phosgene) were very small in amount.

WOOD FIRE NO. 2.

Photograph No. 5:

Specimens 4, 5 and 6 (cleaned after twenty-hours in furnace, and kept two weeks in desiccator); very slightly and uniformly corroded. Others, wiped clean and examined after two weeks in desiccator, corroded decidedly more than 4, 5 and 6.



Photograph No. 5.

Nature of the Fumes.

GENERAL CHARACTER OF THE FUMES IN THE AIR OF THE FURNACE ROOM DURING AND AFTER TESTS. The atmosphere surrounding the furnace during the tests was irritating and objectionable. The fumes were white in appearance, giving the air of the enclosure a slightly foggy aspect due to hydrogen chloride in the presence of atmospheric moisture. The gas was irritating, but the after-effect was slight. The order or taste of sulphur dioxide was detected in the fumes from each fire in which carbon disulphide was present in the extinguishing liquid, but never very strong.

No chlorine was found in the fumes from any of the fires, although the temperature was high enough to cause decomposition of carbon tetrachloride. The absence of free chlorine was due to the fact that both hydrocarbons and water vapor (a product of combustion of alcohol, gasoline and wood) were present in every case in large quantities. Any chlorine formed by decomposition of carbon tetrachloride would probably react with hydrocarbons or water, or both, at the temperatures existing, and form hydrogen chloride.

Table I following contains results of analysis of fumes from the fires which are grouped in accordance with the extinguishing liquid employed.

Table II following (taken from Table I) includes data in a form for comparison of the relative quantities of hydrochloric acid and phosgene as determined by analysis of the fumes from the test fires.

Conclusions.

Composition of Fumes.

The fumes produced when carbon tetrachloride extinguisher liquids of the class indicated above are applied to ordinary fires (gasoline, oil, wood and the like) contain in addition to the usual gaseous products from a fire (including smoke, carbon dioxide and air having a reduced oxygen content) carbon tetrachloride vapor*, small quantities (1 to 2% by volume) of hydrochloric acid (gas) and a slight amount of phosgene (1 to 2 one-hundredths of 1%). Although present in such small quantity, the two latter gases are the two most important ingredients of the fumes to be considered in this investigation.

Corrosion.

The quantity of hydrochloric acid, particularly its concentration and consequently the corrosive action on metals, depends upon the conditions at the fire. The concentration will generally be higher and corrosion greater where access of air is retarded, as in a vault. Under ordinary conditions prevailing at fires, the corrosion of polished steel (tools, etc.) exposed to the fumes will not be liable to result in serious damage to the metal if precautions are taken to remove and clean it promptly following the exposure.

Poisonous Nature.

Under ordinary conditions temporary exposure to the fumes containing hydrochloric acid gas, as in extinguishing incipient and small fires, is not dangerous to life. The exceedingly unpleasant and irritating character of the hydrochloric acid gas acts to prevent very prolonged exposure of operators of extinguishers. While phosgene gas is poisonous, the concentration resulting in extinguishing fires as they ordinarily occur is not liable to endanger life on temporary exposure, but in small closed places, as in a vault, a small closed closet, or cellar room, particularly where the prompt exit of the operator is not possible, there is danger.

Where fires among acids or chemical supplies are to be extinguished by any means, the danger from poisonous fumes should be recognized and safeguarded according to the conditions, irrespective of the type of extinguisher or liquid employed.

Following are comments on the test results and other data in relation to the above conclusions:

Hydrochloric Acid and Phosgene. Although produced in relatively small quantity, these gases are the two most important ingredients of the fumes to be considered in connection with this investigation. As carbon tetrachloride in air alone is decomposed by heat with the liberation of free chlorine, it was expected that the fumes from the fires would contain free chlorine, but the chemical reactions that occur in such fires prevented its production. In cases where a relatively large surface of heated metal may be exposed, some free chlorine will be produced. It was found that large quantities of hexachlor benzole (C_6Cl_6) were formed by contact of carbon tetrachloride and a small gasoline flame inside a box 12 x 12 x 20 inches, but that product did not appear to be formed in an

* Note: CCl_4 vapor probably mixed with other chlorides of carbon.

TABLE I.

	Alcohol Fire No. 1	Gasoline Fires No. 1	Gasoline Fires No. 2	Gasoline Fires No. 3	Gasoline Fires No. 4	Wood Fires No. 1	Wood Fires No. 2	Wood Fires No. 3
Extinguisher Fluid.....	**Market	**Market	6% CS_2 in CCl_4	10% $CHCl_3$ in CCl_4	6% CS_2 in CCl_4	**Market	6% CS_2 in CCl_4	10% $CHCl_3$ in CCl_4
Duration of Fire—Minutes.....	8	7	6	7	8	9	31	25
Temperature at Couple ° F.....	480 to 840	400 to 1200	460 to 1380	766 to 1090	625 to 1340	356 to 840	230 to 1000	400 to 1100
Quantity of Extinguisher } Qts...	5.9	4.4	0.46	3.68	5.24	5.5	11.56	12.1
Liquid Used } Lbs...	19.56	14.69	1.5	12.1	17.1	18.25	37.75	40
Oxygen (dry gas) % by vol.	17.4	19.4	19.6	14.8	14.7	15.5	10.1	16.4
Carbon Dioxide " " " "	5.6	1.5	2.2*	3.6	4.1	4.6	6.6	4.0
Carbon Monoxide " " " "	None	None	None	None	None	None	None	None
Chlorine " " " "	None	None	None	None	None	None	None	None
Sulphur Dioxide " " " "	..	..	..	..	Present	..	Present	..
Hydrochloric Acid " " " "	0.1	2.08	0.10	0.004	0.008	0.16	0.70	1.4
Phosgene Qualitative Test	Present	Present	Present	Present	Present	Present	Present	Present
Phosgene ****—parts per million.	95	2	***	36	160	3	5	149

* Over water.
** By market sample is meant Standard extinguisher liquid obtained on market.
*** Sample tube broken.
**** Variations in % phosgene in the various fires not accounted for.

CS_2 —Carbon disulphide.
$CHCl_3$—Chloroform.
CCl_4 —Carbon tetrachloride.

TABLE II.

Phosgene and Hydrogen Chloride.

Fire	No.	Extinguishing Agent	HCl in parts per 1000 of air	Phosgene in parts per 1,000,000	Parts air to 1 part phosgene
Alcohol	No. 1	Market*	1.0 to 11.2	95	10,526
Gasoline	No. 1	Market*	3.6 to 20.8	Present	
Gasoline	No. 2	6% CS_2 in CCl_4	0.65 to 1.0	Present (trace)	
Gasoline	No. 3	10% $CHCl_3$ in CCl_4	0.04	35.8	28,000
Gasoline	No. 4	6% CS_2 in CCl_4	0.8	160	6,250
Wood	No. 1	Pyrene	1.6 to 7.1	Present	
Wood	No. 2	6% CS_2 in CCl_4	0.7 to 7.0	Present	
Wood	No. 3	10% $CHCl_3$ in CCl_4	0.9 to 14	149	6,710

* Sample of Standard extinguisher liquid obtained on market.

appreciable quantity in the larger test fires conducted in the furnace. Soot composed principally of carbon was formed in large quantity; upon extraction with benzol it yielded a small amount of solid, tarry matter probably made up of a mixture of chlorides of carbon.

CORROSION. The data on corrosion showed that corrosion of metal specimens during exposure to the test fires was slight, but that subsequently serious corrosion occurred unless the specimens were cleaned. The acid character of the coating formed on the specimens was more active on subsequent exposure to moisture, as would be expected, than when kept in a dry atmosphere. Very little corrosion would be required to damage fine polished steel tools, and accordingly the examinations of the specimens were made very carefully.

TOXICITY. Referring to the Tables I and II of results, it will be noted that the maximum concentration of phosgene obtained was very small, 95 to 160 parts $COCl_2$ per million parts of air, or about one to two one-hundredths of one per cent by volume. The minimum effective concentration for military purposes is probably one part phosgene to 2,000 parts of air during one-half minute or 1 to 5,000 for five minutes. It is reported that the lethal dose for thirty minutes is 1 to 40,000. Assuming that the maximum concentration, 149 per million, obtained in the furnace is toxic, it should be considered that this concentration occurred when a relatively large amount of fuel, having a burning surface of more than 12 square feet in the case of liquids, and even more in the case of wood, was exposed to one to five gallons of the sprayed liquid under conditions designed to give a maximum production of fumes inside a furnace to which free access of air was limited. Tests made on a small scale in a box 12 x 12 x 20 inches with both gasoline and alcohol flames gave only traces of phosgene. From these experimental data it appears that there would be danger to the operator of the extinguisher from the fumes formed only in isolated cases, as in small closed compartments where prompt exit after operating the extinguisher is not possible. Possibly such was the case reported by the Navy Department involving the death of two men who attempted to extinguish a fire in a hull compartment of a submarine, the men being exposed to the concentrated fumes over thirty minutes.

In thousands of tests in extinguishing fires with carbon tetrachloride extinguisher liquids no apparent injury to the health of members of the staff of Underwriters' Laboratories has been experienced, although the irritating fumes caused lacrymation and in some cases resulted in a subnormal feeling lasting for several days. These tests were run under varying conditions covering a period of twelve years, and included the use of small rooms partly ventilated, with repeated exposure in some cases for hours at a time.

NOTE: This report was originally dated August 24th, 1920, and was ready for publication at that time. The delay in its appearance has been due to discussion incident to the conclusions drawn.

Further Notes on Tetrachloride
and
A Review of Bureau of Mines Investigation.

By R. S. Moulton.
(Assistant Secretary, N. F. P. A.)

Carbon tetrachloride extinguisher liquids when applied to fires give rise to poisonous gases in quantities which are dangerous in small, unventilated spaces. This is conclusively shown by the foregoing report by Mr. Nuckolls, chemical engineer for the Underwriters' Laboratories, and by a similar and simultaneous but entirely independent investigation by the U. S. Bureau of Mines. National Fire Protection Association members will be interested in a review and summary of this government report, together with a few explanations of chemical terms, supplied by the writer, which it is hoped will make the subject clearer to non-technical readers. This report furnishes data of great interest, partly in corroboration of the Underwriters' Laboratories' work, and partly in supplying additional information on the poisonous or toxic character of the several gases involved.

The Bureau of Mines' report is entitled, "Poisonous Gases from Carbon Tetrachloride Fire Extinguishers," and is the work of A. C. Feldner, S. H. Katz, S. P. Kinney and E. S. Longfellow, of the Research Laboratory, Pittsburgh Experiment Station, U. S. Bureau of Mines. We are indebted to the *Journal of the Franklin Institute* for permission to reprint the extracts quoted in this article. (October, 1920, pages 543-565.)

Before proceeding to a detailed consideration of the subject of carbon tetrachloride, the reader who is unfamiliar with chemical terms and formulae may be helped by the following glossary:

CCl_4—Carbon tetrachloride. Light, colorless liquid, peculiar odor, non-flammable, poisonous.

$COCl_2$—Phosgene (carbonyl chloride). Colorless gas, extremely poisonous. Largely used in the late war as a poison gas.

HCl—Hydrogen chloride (hydrochloric acid gas, muriatic acid gas). Colorless, poisonous gas. (In the arts it is commonly used in solution in water, as muriatic acid, but in this article only the gas is considered. In ordinary industrial processes this is not given off in dangerous amounts.)

Cl_2—Chlorine gas. Heavy, greenish-yellow gas. Poisonous.

All of these gases may be present when carbon tetrachloride extinguisher liquids are applied to fires, or to hot iron (chlorine gas is found only when the liquids are applied to hot iron). They are poisonous, although carbon tetrachloride gas, being in its effects comparable to chloroform, is not to be classed with phosgene and chlorine gas, which are deadly poisons. In open spaces, with good ventilation, these gases will not be formed in quantities sufficient to give a concentration of poisonous fumes dangerous to the operator of the extinguisher. That

1000 cu. ft. gas chamber at the Pittsburgh Experiment Station of the Bureau of Mines; used for the experiments on Carbon Tetrachloride.

they are likely to be dangerous in small, unventilated spaces is convincingly demonstrated by the experiments of Mr. Nuckolls and by the similar but independent, thorough and scientific experiments conducted by the U. S. Bureau of Mines.

Comparison of the Two Investigations.

The Underwriters' Laboratories' investigation by Mr. Nuckolls includes both the corrosive effect of the fumes resulting from applying extinguisher liquids to fires and the toxic or poisonous effects on the operator of the extinguisher. The Bureau of Mines' investigation is not at all concerned with corrosive action, and deals with the subject solely from the standpoint of toxic effect on the operator. In so far as the investigations cover the same field, *i. e.*, toxicity or poisonous effects, the results are remarkably similar. The Bureau of Mines' investigation entirely corroborates Mr. Nuckolls' work in the determination of the character of the fumes in so far as the experiments are comparable. The conditions are not exactly the same, but appreciable quantities of the poisonous gas phosgene are found in both investigations.

The Bureau of Mines' work seems to be a very careful and scientific

laboratory investigation. It goes into careful analysis of all products involved, and uses an elaborate apparatus for making the most accurate determinations possible. The Bureau investigators have apparently made an exhaustive study of the literature dealing with previous work on carbon tetrachloride, and their report is interspersed with frequent footnotes referring to a bibliography including the French and German as well as the works on this subject published in English.

The Bureau of Mines' investigators used a gas-tight room, 1000 cubic feet capacity. This is illustrated herewith. Actual fires were built in this room and the carbon tetrachloride liquids were applied by operators using ordinary extinguishers. These operators were protected by wearing the Army type of gas mask. This gas-tight room precluded the ingress of any air and also insured the collection of all the products of combustion or of decomposition of the carbon tetrachloride. Mr. Nuckolls' method was slightly different, in that his chamber was not gas tight; that a small supply of air to simulate probable actual conditions was admitted to the bottom of the furnace; and that liquids were sprayed rather than applied by an operator. The Bureau of Mines used not only actual fires, but in some cases the liquid was squirted on red-hot iron to represent the conditions which might obtain if carbon tetrachloride extinguishers were used where welding was in progress.

The Underwriters' Laboratories withdrew their samples through a tube opening directly above the fire, while the Bureau of Mines' investigators waited to get a uniform distribution of gases throughout the chamber before withdrawing their samples. This perhaps accounts for the fact that the Bureau report shows in general lower concentrations of noxious gases. These differences in method between the two investigations, while at a first glance might appear to be likely to influence the results, in the light of the results obtained do not appear to be materially different in any important respect.

The extinguisher liquids used by the Bureau of Mines were commercial carbon tetrachloride and various commercial extinguisher liquids obtained in the open market. Analysis of these showed that they contained in addition to carbon bisulphide present as an impurity in the original tetrachloride, either chloroform, turpentine or flammable petroleum oil. It is explained that these latter ingredients are added to depress the freezing point of the carbon tetrachloride, which in its pure state is about -9° F. The liquids used by Mr. Nuckolls were commercial extinguisher liquids and mixtures made for the purpose of the experiment, and contained percentages of chloroform and carbon bisulphide apparently somewhat larger than the percentages of these substances used in the Bureau test liquids.

The quantities of phosgene, hydrogen chloride and carbon tetrachloride vapor found are shown by Table I (top of next page), which summarizes the results of the several Bureau experiments. This table is condensed from the original by the elimination of columns showing quantities of relatively harmless gases present, and by changing units from the metric system in the original report to the ordinary units shown. The abbreviation P. P. M. means parts per million. CCl_4 is carbon tetrachloride; HCl, hydrochloric acid gas; $COCl_2$, phosgene; Cl_2, chlorine gas, as explained in the glossary on a preceding page.

TABLE II.

Toxicities of Air Containing Gases and Vapors from Fire Extinguishers.

	Carbon tetrachloride	Chlorine	Chloroform	Hydrogen chloride	Phosgene
Least detectable odor:					
Parts per million	718	3 5	674	.....	5.6
Irritation:					
Eyes:					
Parts per million	.....	.....	.....	.....	4.
Throat:					
Parts per million	.....	15.1	.....	.....	3.1
Coughing:					
Parts per million	.....	30.2	.....	.....	4.8
Slight symptons after several hours:					
Parts per million	1600	1.	200	10	1.
Maximum amount that can be inhaled for one hour without serious disturbances:					
Parts per million	4000-6200	4.	5100-6200	50-100	.....
Dangerous in thirty minutes to one hour:					
Parts per million	24000-32000	40-60	14000	1500-2000	.....
Noxiousness, impossible to breathe several minutes:					
Parts per million	.....	5	.....	66-200	5
Toxicity of lethal dose:					
Mice, 10 minute exposure:					
Parts per million	.....	.....	>25900	.....	99
Dogs, 20 minute exposure:					
Parts per million	.....	860	.....	.....	86
Cats, 30 minute exposure:					
Parts per million	63000	.....	25000	.....	50
Man, 30 minute exposure:					
Parts per million	48000-63000	.....	.....	1000	25
Kill most animals in very short time:					
Parts per million	48000-63000	1000	62000-82000	.....	.....
Physiological action of gas	Asphyxiant	Respiratory irritant	Asphyxiant	Respiratory irritant	Lachrymator-respiratory irritant

TABLE I.

Results of Experiments with Heated Carbon Tetrachloride Fire Extinguisher Liquids in the Closed Chamber.

Experiment No.	Liquid used	Volume of liquid used qts.	Source of heat	Estimated temp. °F.	Results of analyses				Color of smoke
					CCl_4 P. P. M.	HCl P. P. M.	$COCl_2$ P. P. M.	Cl_2 P. P. M.	
1	Com'l. CCl_4	.85	4 inch "I" beam	1520	4350	144	168	0	Yellow like chlorine (1)
2	Ditto	1.06	6 in. channel	1110	5850	...	80	23	Ditto (2)
3	Ditto	1.06	Excelsior fire	....	5130	110	60	0	Red-brown, nearly black
4	No. 1	1.06	Ditto	....	4970	82	15	0	Ditto (3)
5	No. 2	.32	Ditto	....	2000	65	19	0	Ditto (4)
6	No. 1	.42	6 inch channel	1520	2607	60	30	10	Yellow like chlorine (5)
7	No. 2	1.06	6 inch channel plus 4" "I" beam	1742	2078	236	42	0	Black (6)

REMARKS:
(1) Odor of CCl_4 and HCl was noticed.
(2) Phosgene could be detected by odor.
(3) Could detect HCl and $COCl_2$ by odor.
(4) Could detect HCl and $COCl_2$ by odor.
(5) Could detect HCl and $COCl_2$ by odor.
(6) Liquid burned on iron with a flickering flame.

It is interesting to note that this table shows chlorine gas in two tests where the Laboratories' experiments fail to find chlorine in any case. The chlorine was found in tests with hot metal (no similar test being made by Mr. Nuckolls) and not in the fire tests. This indicates either that iron is necessary to form any considerable quantity of chlorine, or that with fires the chlorine gas was absorbed by other products of combustion.

While the experiments in the closed room gave results which simulated the action of carbon tetrachloride liquids in actual use, these tests did not give opportunities for controlling the temperature and humidity factors influencing the decomposition. In order to observe results with these factors subject to control, the Bureau experimenters decomposed carbon tetrachloride by passing through a heated tube, and collected the products of decomposition. It was found that with the conditions thus controlled it was possible to obtain very much larger proportions of noxious gases than had been recorded in the closed room. In some cases phosgene was obtained in quantities up to 4000 parts per million of the resulting gases. Chlorine and hydrochloric acid gases were also obtained. This indicates that the proportion of noxious products depends very largely upon conditions, and that it is theoretically possible under the right fire conditions to obtain larger proportions of phosgene and hydrochloric acid gases than were recorded in the results of the closed room experiments.

The Bureau of Mines' paper includes a careful tabulation of the existing data on the toxicity or poisonousness of the several gases involved and is very valuable for purposes of comparison. The table reproduced herewith (Table II) is condensed from the original report with the

elimination of certain references and equivalent figures in the metric system. The table shows that the relative order of toxicity is (1) phosgene; (2) chlorine; (3) hydrochloric acid gas; (4) carbon tetrachloride; (5) chloroform. Comparison of Table I, showing the quantities of toxic or poisonous gases found, with Table II, showing the toxicities or poisonous properties of these gases, is very interesting.

From Table I we find that carbon tetrachloride vapor may be present in quantities of from 2000 to 5850 parts per million. Table II shows that this amount is less than the maximum of 4000 to 6200 parts per million which can be inhaled for one hour without serious disturbances. It is less than one-tenth of the concentration required for the lethal or fatal dose for a half-hour exposure.

From Table I we find that hydrogen chloride (hydrochloric acid gas) may be present in quantities of from 60 to 236 parts per million. By comparison with Table II, it is seen that this amount can not be inhaled for one hour without serious disturbances. It is, however, much less than the concentration of from 1000 to 2000 parts per million, which is dangerous after a half-hour exposure.

From Table I we find that chlorine gas, present only when the extinguisher liquids are applied to hot iron, may have a concentration of from 10 to 23 parts per million. From Table II it is seen that this is considerably in excess of the four parts per million which can be inhaled for one hour without serious disturbances. It is of sufficient concentration to irritate the throat and be impossible to breathe for several minutes. It is, however, very much less than the concentration necessary for fatal effects.

From Table I we find that phosgene may be present in concentrations ranging from 15 to 168 parts per million. From the phosgene column of Table II it appears that five parts per million is impossible to breathe for several minutes, and that 25 parts per million is fatal after a half-hour exposure. Thus the quantities of phosgene found in the closed room experiments by the Bureau of Mines were such as to be fatal to man in a half-hour, or with a much shorter exposure in the case of the higher concentrations.

The following, quoted from the Bureau of Mines' report, gives their summary:

Summary and Conclusions.

As a result of the death of two men in the Navy Department from breathing fumes from carbon tetrachloride used on a fire, and the overcoming of an employee of the Bureau of Mines while fighting a fire with carbon tetrachloride liquid, an investigation of the decomposition products of carbon tetrachloride fire extinguishers was made. Experiments were conducted by two methods. The first consisted in applying the liquids to actual fires and to hot metal in a closed room of 1000-feet capacity where the gaseous products, mixed with the air, could be retained and analyzed. The second method was to pass the vapors in air through heated tubes of iron or quartz, where humidity of the air and the temperature could be controlled.

These poisonous gases were found in the air of the gas chamber: Phosgene, which is intensely poisonous, was formed in toxic quantities. Chlorine, which is also poisonous, was formed in smaller amounts. Hydrogen chloride,

which is irritating and also poisonous, was formed. And there was considerable vapor of carbon tetrachloride, which is a dangerous anæsthetic. The experiments with the heated tubes substantiated the results found with actual fires, and indicated that these reactions can account for the poisonous gases. (Explanations of equations, indicating way in which noxious gases may be formed, are added by the reviewer).

CCl_4 Carbon tetrachloride	+	H_2O water	➡	$COCl_2$ phosgene	+	2 HCl hydrochloric acid gas
2 CCl_4 Carbon tetrachloride	+	O_2 oxygen	➡	2 $COCl_2$ phosgene	+	2 Cl_2 chlorine gas
3 CCl_4 Carbon tetrachloride	+	Fe_2O_3 iron oxide	➡	3 $COCl_2$ phosgene	+	2 $FeCl_3$ iron chloride
2 CCl_4 Carbon tetrachloride	+	Heat	➡	C_2Cl_4 tetrachloroethylene (carbon bichloride)	+	2 Cl_2 chlorine gas
CCl_4 Carbon tetrachloride	+	2 H_2O water	➡	CO_2 carbonic acid gas (carbon dioxide)	+	HCl hydrochloric acid gas

One-half of the carbon tetrachloride liquid was decomposed to poisonous gases in some of the tube experiments.

As a result of the experiments, it is recommended that carbon tetrachloride fire extinguishers be not used on fires in closely confined spaces where conditions are such that the user cannot escape without breathing the fumes. The Army type of gas mask offers good protection from the fumes.

It is not the intention of this paper to discourage the use of carbon tetrachloride extinguishers, which are excellent for stopping incipient fires, but rather to point out a danger which can occur with their application.

The average user of a carbon tetrachloride extinguisher does not know that the decomposition products are poisonous. It would, therefore, seem that manufacturers of such apparatus should put a plainly lettered caution plate on each extinguisher, stating that the fumes from using the extinguisher must not be inhaled, as they are poisonous.

These conclusions, although based on very similar data, are much more radical than those reached by Mr. Nuckolls. The caution that "the Army type of gas mask offers good protection from the fumes," and the suggested caution plate on the extinguisher are perhaps rather extreme. The conclusions to be drawn from the Bureau of Mines' tests are the same as those obtained by Mr. Nuckolls. They both give interesting data as to the character of the gases formed, and show that it may be dangerous to use carbon tetrachloride extinguishers in small, unventilated spaces. This fact, however, should not detract from the availability of this type of extinguisher to protect those hazards to which it is peculiarly suited.

The Firing and Explosion of Flour Dust.

By James Scott.*

Although, fortunately, disastrous fires and explosions due to the presence of dust are comparatively rare, there is always the possibility of such catastrophes occurring suddenly without the slightest warning. The subject is, therefore, one not only of direct interest, but of very great importance to the reader.

It is well known that carbonaceous and oily kinds of inflammable dust are liable to be fired and blown up by what is called, for want of a better term, spontaneous ignition. No settlement has been made relative to the actual causes which start such conflagrations. The suggestions may, however, be roughly grouped into three classes, viz., by means of sparks, static electricity and flame. Each theory has its strenuous supporters who do their best to discount the value of other ideas. No benefit would accrue by vigorously acclaiming a belief in either one; and the problem as to the real start of fire or explosion must be regarded as still remaining open.

It is thought in many quarters that until fans were introduced no very serious fires or explosions happened. But old millers know that before that time mysterious flashes were often visible as one went through a mill with a candle alight or an open lamp. Minor fires were undoubtedly prevalent, but fans assist the destructive process by creating draughts and carrying any originating spark or flame into denser dust-packed spaces, so that they evidently accentuate the danger.

Sparks consist of white hot particles of detached mineral matter springing from grinding stones; and similarly conditioned metal from hot bearings of the purifiers. They act upon suitable dust clouds in a way similar to the old flint sparks which ignited prepared tinder.

Static electricity is that which is induced by friction, the most familiar examples being those produced by rubbing rods of glass, amber, and so on, with fabrics. It is often evolved in very unsuspected places. It is induced in driving belts and other moving parts of machinery.

The state of the air at the time of trouble is very likely to augment the course of events. On dry, hot summer days it appears to be extremely electrical, and would favor the spontaneous ignition of moving or floating dust.

In the year 1914, throughout the Pacific Northwest, three hundred threshing machines were destroyed by means of static electricity, firing and exploding the contents. Certain parts of the apparatus developed force sufficient to set light to the flour, etc., with the result that the suddenness of the expansion of gases thereby caused in the confined spaces broke the chambers completely open or scorched them beyond repair.

* Reprinted through courtesy of *Milling*, Liverpool.

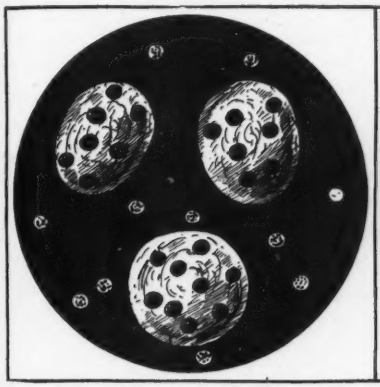


Fig. 1.—Three granules of wheat starch (flour) bearing oily, inflammable smut spores of Ustilago fungus; some of these being also shown loose; magnified. Actual size of the starch granules is about one-thousandth of an inch.

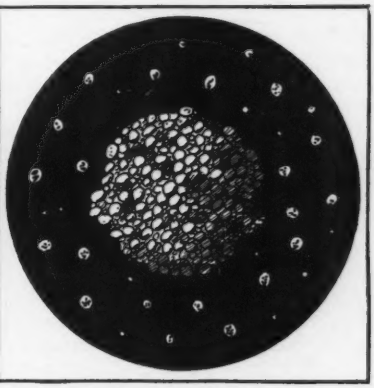


Fig. 2.—A cluster of starch granules of wheat, about a fiftieth of an inch wide, with floating single granules round it; magnified. These expand when heated.

Owing to the presence of numerous smut balls (collections of fungus spores), it was believed that their oiliness accelerated the disaster. How far the presence of spores of this nature may influence the susceptibility of cereal dust towards firing it it is difficult to say, but I do know that they occur in flour and meal to a much greater extent than is generally known. This is the fault neither of the farmer nor miller, because the spores I have in mind generally grow and reproduce themselves inside the endosperms or kernels of wheat, etc., quite unseen and undetectable until they assume epidemic proportions. They can be found, of course, by intentional, long search.

In the baking of the flour into bread they are destroyed and rendered innocuous, unless they are very numerous; and in the latter case their darkening of the flour would make them noticeable, and probably entail rejection or further cleansing. My impression is that, supposing a chamber to be full of pure flour dust, it would not be so liable to rapid ignition as would be the case were a certain percentage of the granules accompanied by the oily spores of secretive fungi, which would serve a purpose similar to the lighted paper and wood laid in a grate in their action upon the coal—that is, a factor enabling the already sensitive dust to become more dangerous than it would otherwise be. You cannot light coal with a match; nor can you light flour dust with the same thing. But once having started coal at a sufficiently high temperature, through the action of a match on paper and wood, the remainder will eventually blaze up energetically. So, too, I think that a spark which would not set light to absolutely normal dust would be capable of igniting spore-laden grains; and these would pass on the flame to the rest of the dust, which (like the coal without paper and wood) would not act so without the intervening medium.

This course of events would explain why, although many mills are constantly flour-laden to the same degree as one another, and are exposed

to similar working conditions, only one or two instances of fire or explosion supervene. Suppose that spore-bearing flour is carried inadvertently about the premises on one or two occasions. This might—I do not say would, because evidence is hard to collect or prove—be responsible in the manner outlined for generating all the damage involved by a fire or explosion. Some spores are shown in Fig. 1, magnified to the same relative dimensions of the flour granules, many of which are the *same* size, or even smaller, than these spores.

With the view of affording enlightenment on the *behavior* of flour dust in circumstances of the character contemplated, I made several experiments, the details of preparation for which need not be given. I satisfied myself, however, that such dust is really difficult to ignite; but when once it *has* been so treated, either naturally or intentionally, the resultant fire will spread with amazing celerity, and, of course, in confined areas bring about an explosion.

It is repeatedly said by investigators that as flour dust is not in a gaseous form it cannot act as a gas. Now, I have learnt that although the granules do not themselves compose or give off gas in the ordinary way, they can soon become the equivalent of a gas, and practically the same as one.

If some flour dust is spread on glass and warmed over a spirit flame, it is not long before it becomes brown and, then black. Meantime, a white vapor can be seen rising from it, and if a match is applied thereto a flame will appear on the flour, and it will henceforth burn to a char or carbon.

Flour is a carbohydrate, and contains carbon, hydrogen and oxygen; the two latter elements existing in the same combined proportions as they are in water. In burning flour, the only gases we can *theoretically* expect to produce flame are hydrogen and carbon monoxide; the final gas, after combustion is completed, being non-flammable carbon dioxide, with which water is associated.

I do not believe that the process is so simple as is implied by this theory. Neither hydrogen nor carbon monoxide are visible; yet before the flour is purposely ignited we can *see* the vapor. (If caught on glass, it gives a tarry film.) Some people would call this steam, but you cannot ignite steam in the ordinary way. If it comes into contact with incandescent matter, steam can be split up into its respective components, hydrogen and oxygen; the first of which will then burn as a flame, being assisted to do so by the second.

The fact that by applying a light to the vapor described it gives flame proves that it either contains inflammable gas, or is split up into kindred substances. My own conviction is that during the heating of flour, if it goes above a limit of temperature, a kind of resinous matter is produced in it, its presence being signified by the browning of the flour. It seems to be impossible to isolate this resinous matter; but it would resolve the flour into an extremely inflammable substance—far more so than a mere carbohydrate is expected to be. It would not be possible to trace such resinous matter in the carbon of the consumed flour, because all kinds of fine soot are the same as one another, except for impurities.

(By the way, I have derived minute balls of red resin from wheat specially treated; but the particulars respecting its formation are not

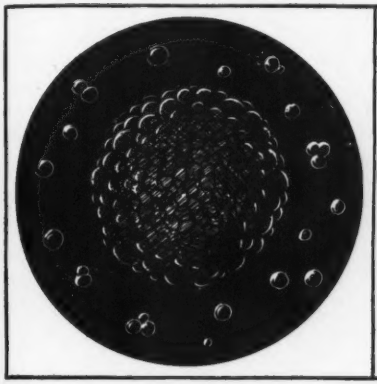


Fig. 3.—The cluster, etc., of starch granules shown in Fig. 2 are here expanded into globules, the individual ones being transparent; magnified.

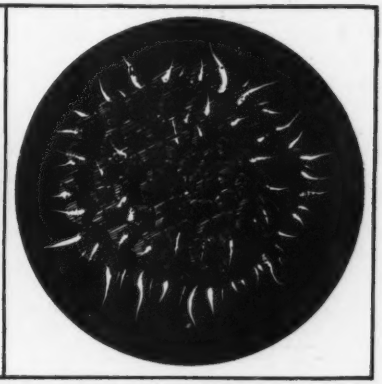


Fig. 4.—The same cluster of starch granules, bursting through excessive heat, and giving rise to jets of flame, which ignite the other granules in the vicinity; magnified.

appropriate to the subject selected for today's consideration, so that further reference thereto must be postponed.)

It cannot be pretended that we know all that is possible of the chemistry of flour starch, which is accompanied by gluten or nitrogenous content, or else can yield it under given, obscure conditions.

During the war a synthetic resin was made by the reaction of formaldehyde on phenol (*i. e.*, carbolic acid). When this was dissolved in spirit it gave a varnish which was used for covering the insides of the cardboard substitutes for glass jars and tin cans for holding jam, etc.

It has been discovered that formaldehyde plays a mysterious part in connection with the creation and modification of starch. But as these phases are still in the experimental stages, I will leave them alone for awhile.

Starch is a decidedly remarkable substance. When strongly heated in receptacles from which excess air is excluded, it shrivels and changes from an insoluble to a soluble state, its solution in water then forming dextrine, or stamp and envelope gum.

In Fig. 2 is shown a minute cluster of wheat starch grains—*i. e.*, flour. However dry flour is to one's senses, its particles mostly stick together in this manner, but they are too small to be seen with the naked eye. When the flour is heated, each granule swells until it becomes a globular bladder. Meanwhile the contents are curiously changed and gasified. Usually the bladders discharge their vapors and finally shrink together into a honeycomb or net-like mass (the figuring is caused by the united walls or skins of the swollen granules) if the application of heat continues. This transition is shown in Fig. 3.

If the heat is strong enough, such as it would be from a travelling flame, fine streams of inflammable gases burst out from the collapsing bladders and are set alight, as shown in Fig. 4.

Let us presume that a spark, or other exciting cause, ignites some flour dust, possibly laden with fungus spores. The small flame instantly

expands the granules in its closest vicinity, and the gases which emerge from these ignite. Soon there is a long sheet of flame, which rushes through the rest of the dust cloud, and with lightning-like rapidity gasifies the other granules.

Essentially, although the flour is only dust, the immediate effect of its transformation is analogous to the place being filled with gas, because the myriads of minute globes eject inflammable gas at a wonderful rate; oncoming *heat* drives this gas out and then the flame ignites it. It does not wait for the flame itself to burn the particles before it (the gas) emerges. There is a distinct and effective difference between the two processes.

Cow Blows Up After She Drinks Gasoline.

CLEBURNE, Texas, Oct. 19.—One cow exploded and another died as the result of gulping gasoline here Monday afternoon.

The cows lapped up a tub full of gasoline which stood before a local garage. It was necessary to take drastic measures if lives were to be saved.

Taking a long steel instrument the veterinary punctured the side of one of the animals. Gasoline started to trickle out. The medico turned aside for a moment and lit a cigarette. His patient exploded with a black cloud of smoke.

Strange to say the gasoline explosion did not kill the cow which cavorted madly down the road with a jet of flame spurting from its side The animal was caught and the blaze extinguished. It will live.

The other cow, which was not punctured, died.—*New Orleans Times-Picayune.*

Field Tests of Dry Pipe Valves.

By Canadian Fire Underwriters' Association.

(Member N. F. P. A.)

In the self-inspection report blank recently issued by the National Board of Fire Underwriters, there is a recommendation for at least an annual tripping of dry pipe valves, and the experience of several associations in Canada over a considerable period strongly emphasizes the value of this advice. Climatic conditions encourage a greater percentage of dry pipe sprinkler systems in Canada than in more southerly climes, and about ten years ago the need for field tests of dry pipe valves was forcibly impressed by the failure of several upon inspection. With the growing experience, and for greater uniformity in the testing, a special blank was prepared five years ago, with the assistance of the Underwriters' Laboratories, and a copy of each report is filed with that organization.

A special review of reports in the N. F. P. A. files shows that of failures of dry pipe systems 10 per cent are due to failure or slow operation of dry valve. The tabulation includes only systems "on air," and does not include those "under water." It is a tabulation of failures only, not including any fires where the operation of the sprinklers was satisfactory. This table is appended to the end of this article.

The percentage of failure in our fire and field tests and under other conditions has been very small as a whole, but varying materially with the type, make, pattern and model. Some valves have almost a clean record for the entire period, while others have made a very unfavorable showing. For obvious reasons, details cannot be supplied. This article is not intended as an argument against the reliability of the dry pipe valve as such, but to advocate regular field tests and the selection of the most suitable dry pipe valve for the conditions under which it is to be installed.

The major "casualties" have annually averaged over five for ten years and have disclosed conditions under which valves would undoubtedly have failed in a fire, where such has not actually happened. While the percentage of failures under both fire and field tests is small, it must be recognized that the number of valves operating under fire conditions is only a very small percentage of the total installed. This is true generally of sprinkler devices, and therefore field tests will be a decided factor in determining their reliability for service.

While dry pipe valves have operated properly after being set "dry" for a considerable number of years, such a long delay in testing is felt to be poor practice, and is not the general rule with other portions of a sprinkler equipment, such as fire pump, alarm valve, water supplies, and so forth. The reliability of a whole system may be dependent upon the proper operation of the dry pipe valve, and it should therefore be tripped regularly.

The failure of a dry pipe valve does not necessarily imply an inherent defect, but may be due to improper setting, substitution of or addition to parts, poor maintenance, local surroundings, condition of water supply or other causes. Poor shop practice or structural defect has, however, contributed to some failures, making necessary the replacement of the valves to avoid courting disaster in case of fire. On the other hand, successful operation in a number of trials does not necessarily imply continued good behavior, or safety in a discontinuance of the tests, for such valves have subsequently required replacement due to failure. Interesting features developed by our experience may be of benefit, and are therefore related.

Failures in Fires.

There have been two failures in fires, but one was not charged directly to the dry pipe valve, owing to the replacement of a missing small part by a home-made piece which threw the adjustment out of line. The other valve failed to operate in a fire opening twenty-one heads. At subsequent immediate tests, it was found that under certain adjustments of the set screw there was a binding of one of the parts. The reason assigned was too soft metal for the bearing surface of the set screw, which formed a groove when set up too tight.

In addition, there have been two total losses of sprinklered properties protected by dry pipe systems. In one case, a frozen supply pipe to the valve was assigned as the cause, the valve being found open after the fire. In the other, there were two dry pipe valves, one opened partially and the other did not operate; but so far as could be determined, the controlling gate valves under the dry pipe valves were shut at the time of the fire, and the failure of the equipment was attributed to that. In one other case, the loss was thought to have been increased by the slow operation of the dry pipe valve, which was of an obsolete pattern.

Failures in Field Tests.

Corrosion, Rust, Scale or Sediment prevented the operation of seven different valves of five different patterns of both the differential and mechanical types. In two cases, the failure was reported by the property owner and investigated by this Association. Failure of an eighth valve was attributed to white lead having been spread over the air clapper when installing the valve. In still another case, the hand hole plug blew out when the valve tripped, due to corrosion of thread in the valve body.

Sticking, mainly in the auxiliary air cup, caused ten failures of seven valves. A gasket or washer was found inserted in the air cup in some cases. On another occasion, with one of the valves a releasing part became wedged between the body of the valve and the rod of the water clapper, and prevented the valve opening to full capacity. With another pattern of valve, stones forced up by the water pressure prevented the water clapper going into place, and caused a failure of the valve.

Ice. Ice in the anti-column pipe prevented the operation of one valve in a cold storage warehouse, with a further repetition if a by-pass had not been provided in the warm valve closet subsequent to the first test.

Water Columning. At three separate properties, over as many years, seven different valves were found deliberately "water columned,"

the object being to rust up leaks and at the same time maintain the alarm service, the intermediate chamber being drained. It was not realized by those responsible that the valves could not operate under such conditions, although in two of the cases the foreman of the installing company was at fault.

Four valves reseated during test, due to trouble with the latch.

Poor Shop Practice or Structural Defects. Incomplete finishing of castings, defective castings, poor alignment of or omission of parts or general defects contributed to failure or poor operation of four valves and replacement of eight, and to the temporary interruption of four other systems while replacing parts.

Fractures of Valve Bodies or Pipe System. Four fractures of valve bodies, five more of 5-inch or 6-inch fittings of the pipe system above the valve; one of a sprinkler on the line, one of a pressure gauge, and several severe water hammers which alarmed the occupants of the buildings, who thought there had been an explosion, have occurred at six different properties in four widely separated places and under varying conditions of installation. The first occurrence of the kind was in 1915, with the others following in different years to 1920, and on two different patterns of valves.

Where the bodies were broken, the valves were subsequently replaced with those of a heavier casting, followed in one case by breaks on the pipe system. In another, the valves withstood the water hammer, but the shock was sufficient to pull the 5-inch feeder passing through the brick wall of the valve chamber back about five inches. At still another property, where there was a heavy water hammer, persons stationed at the valves stated that they had raised off their bases.

In each case recited, the trouble has occurred on the system that stood "under water," that is, where the dry pipe valve had been previously tripped. In five of the properties the dry pipe valves were on what is known as a "header"—two or more valves on one supply main. In the sixth property, with two casualties two years apart, while there were several groups of dry pipe valves, each valve had a separate connection from the yard system, with a minimum run of supply main between valves of 75 feet and a maximum of 150 feet, and the 5-inch fitting that broke in the first accident was 200 feet, following the pipe line, from the dry pipe valve that had just been tripped.

Two of the accidents were not in field tests, one being a demonstration by the sprinkler foreman to show the property owner the operation of a dry pipe valve on a new system. In the other the property owner had allowed one system to trip, and it had stood under water for some days when an adjoining valve was also permitted to trip, and a piece about 11 x 4 inches was blown out of the first valve by the resulting water hammer. Several similar occurrences have been reported from other fields, and they all appear practically identical with the recent accident in the New England field resulting in a very heavy loss. (See report of this fire on page 255.) In that case, two out of three dry pipe valves were "under water," the fire opened the sprinklers on the third system that stood "on air." The water hammer which followed the tripping of this third valve ruptured one of the other two, with consequent failure of the sprinkler system and the total destruction of the building.

Expert opinion was sought directly after the first fracture in 1915, and continued investigation finally assigned the cause as the reseating of the air clapper, with consequent sudden arrest of the column of water moving downward in the riser of the valve first tripped and standing "under water." This sudden stoppage results in a severe water hammer, with consequent rupture of any weak part in the valve itself or the pipe system above same. All of the breaks have occurred above the air clapper. With the tripping of a dry pipe valve, a large connection, usually 4 inches or 6 inches, is opened instantly, with a consequent heavy temporary drop in the water pressure, followed by a movement of water not only from the source of supply to the second valve tripped, but also from the pipe system of the first valve tripped on account of the head of the column of water, further accelerated by the air compressed in the system. To the back rush of water through the valve is attributed the reseating of the air clapper. This has occurred both with valves on headers and those fed singly from yard main, and could occur under similar conditions in entirely distinct properties fed from the same source of supply, if within the sphere of the temporary low pressure.

The standard specifications for dry pipe valves do not permit the reseating of the main air and water clappers after the operation of the valve, to obviate other difficulties than those above mentioned; but a careful record kept for several years shows that many air clappers have reseated in our field tests, whether the valves were single or on a header. Steps are now being taken by the manufacturer to overcome this difficulty.

The arrangement of some of the connections has been questioned, likewise the method of conducting the field tests; but the latter is considered no different than is likely to happen in actual practice, as illustrated by one case recited above, also by the fire loss mentioned.

The installation of dry pipe valves on a "header" has been criticised as not the best arrangement, due partly to the long run of pipe from the valve to the system; but it is the most practicable and economical arrangement under many circumstances. If, however, the dry pipe valve is always to be located close to the system which it supplies, it will entail in many cases a large added expense in protecting the supply main against frost. It will also involve additional dry pipe valve enclosures with the necessary heating, and the danger of a possible water damage during the operation of the valve if situated upon an upper floor. A large number of dry valves, both of mechanical and differential types, have been tested on headers, arranged with all of one type or a combination of types on the same header. The casualties are outlined above. The cause for them is believed to have been found. It should be noted, however, that owing to objection to the regular method a number of tests on "headers" with mechanical types have been conducted with all valves "on air" or controlling gates shut, except with the valve under immediate test, to avoid any possibility of accident. Very few cases of water hammer have been recorded in the tests of valves of the differential type, and only two were severe and with no injury to the sprinkler equipment. In one case, during the test of a number of valves, a 4-inch main in the street in front of the property broke. This main did not supply the sprinkler equipment, and it is not known whether a water hammer created during the testing was responsible. None was apparent at the valves.

Leakage.

WATER CLAPPERS. There has been excessive leakage on three valves on four tests, due to water clapper not seating properly, charged respectively to loose spindle, to scale, to releasing-part becoming wedged, and to pieces of rock—the last two previously mentioned above.

INSUFFICIENT BOLTING OF COVER PLATES—BALL DRIPS. In a few cases, cover plates have been found not bolted tight, causing leaks, but not sufficient to affect the efficiency of the system.

Many minor and some severe leaks at ball drips were due to sediment, rust or scale. These, taken with those at water clappers, show the necessity of an ample drip pan connected to a drain, underneath dry pipe valve if installed on an upper floor. In one case there was a severe leak at piston plunger due to a cinder keeping it off its seat.

Large pieces of lead forced up by the water pressure were taken from underneath the water clapper of two dry pipe valves, and there have been a number of cases of small stones removed from the interior of dry pipe valves, but which did not prevent their operation.

Tripping Points.

On many tests of both types the tripping point has varied materially from that designated for the valve, and mainly on the low side, a number being reported zero, especially with the piston type. It is, however, exceedingly difficult with the small-faced dial on the average pressure gauge to ascertain the exact tripping point. One of the sprinkler companies prepared a special test apparatus with a large-faced dial registering to 40 lbs. and with a relief valve to protect the gauge from pressures beyond that until the gauge could be shut off. The controlling valve, however, could not be closed quickly enough, and the first test proved the last for this particular apparatus.

There have been high tripping points and, in this connection, where a dry pipe valve has supervisory service its tripping point should be determined before the supervisory low air signal is adjusted; otherwise the low air and water-flowing signals may be received so close together as to preclude any attempt to restore the air pressure after the receipt of a low air signal.

Water Flowing Tests.

The tripping of a dry pipe valve also offers a most satisfactory method for a water flowing test. Under average conditions, a system should equalize in 15 to 30 seconds after the valve operates—that is, the pressure gauges on the supply and system sides of the dry pipe valve should register alike. If there is a delay of over a minute in this equalization, it should be investigated to determine the cause, for the average of many tests is less than half that time, as already indicated. The Underwriters' Laboratories were very insistent on this point, and its value has been amply demonstrated.

A slow equalization may be due to a large or complicated system of interior piping, or to a weak water supply, but it may also indicate some obstruction or other defect in the system or its supply. In our field tests, it has already disclosed a hitherto unknown city gate valve, found more than half shut, in an 8-inch connection to a yard system, and which had

undoubtedly been that way for some years; also severe leaks in the yard system of the same property. In other properties the wedges of two gate valves which had become detached from the spindles were found nearly blocking the supply pipes to dry valves; a piece of lead from joint of underground main was discovered lodged between the clapper and the bonnet of check valve at city connection, which prevented its opening wide; a large number of sprinklers on a supposedly wet portion of an equipment were found to have been connected to the dry section through only a 2-inch pipe. Testing through the ordinary 2-inch test pipes did not disclose the above defects.

Cross Connection of Alarms.

It has also been found, especially on small systems where the major portion of the equipment is wet pipe, that the equalization on the tripping of the dry pipe valve is so rapid that the alarm valve does not have time to respond, subsequent test proving it in order. The alarm connections from the dry pipe valve should therefore be cross connected, with proper gates and checks, with those from the alarm valve; otherwise it is possible for the dry pipe system to fill with water through loss of air and, provided there is no open discharge, without operating the alarm valve. In cold weather this might cause damage to the system.

Summary.

Test dry pipe valves annually, all covers to be in place. Clean dry pipe valves thoroughly before re-setting. Cross connect alarms with those from alarm valve where on same system.

Causes for Failures of Dry Systems.

A Table Compiled from N. F. P. A. Fire Reports, Including Only Failures of Systems "On Air".

	No. of Fires.	Per cent of Known Causes.
Failure of Dry Valve, or slow operation	27	10.08
Water shut off—all causes	63	23.51
Defective water supply	43	16.05
Unsprinklered portions	27	10.06
Explosion or building collapse, crippled system	16	6.34
Generally defective equipment	13	4.85
Faulty building construction, concealed spaces	13	4.85
Obstructions to distribution	13	4.85
Exposure or conflagration	11	4.10
Hazard of occupancy too severe	10	3.73
Freezing	9	3.36
Defective heads (including high test heads)	8	2.99
Plugged heads	8	2.99
Miscellaneous	6	2.24
Total	268	100.00
Unknown	10	
Total	278	

Dry Valve Failure in American Woolen Co. Fire, Medford, Mass.

By Gorham Dana.
(Member N. F. P. A.)

During the last few years there have been several cases of breaking of Manufacturers No. 3 Dry Valves, due to water hammer in case of fire. This can occur where more than one dry valve is set up on a header and where one of the systems is full of water when one of the other valves trips. There is a sudden drop in pressure at the header when the water flows into the system, and this causes a down flow in the system which is full of water. This down flow causes the check valve at the top of the dry valve to shut suddenly, thus creating a severe water hammer. The manufacturers discovered this defect some years ago, and in 1916 the casting of the valve was thickened to overcome the difficulty. It is probable that only valves issued before that date are likely to develop this defect.

It is possible for similar trouble to occur in other makes of mechanical valves where there are check valves similarly arranged, but this is the only valve where we have a record of such trouble.

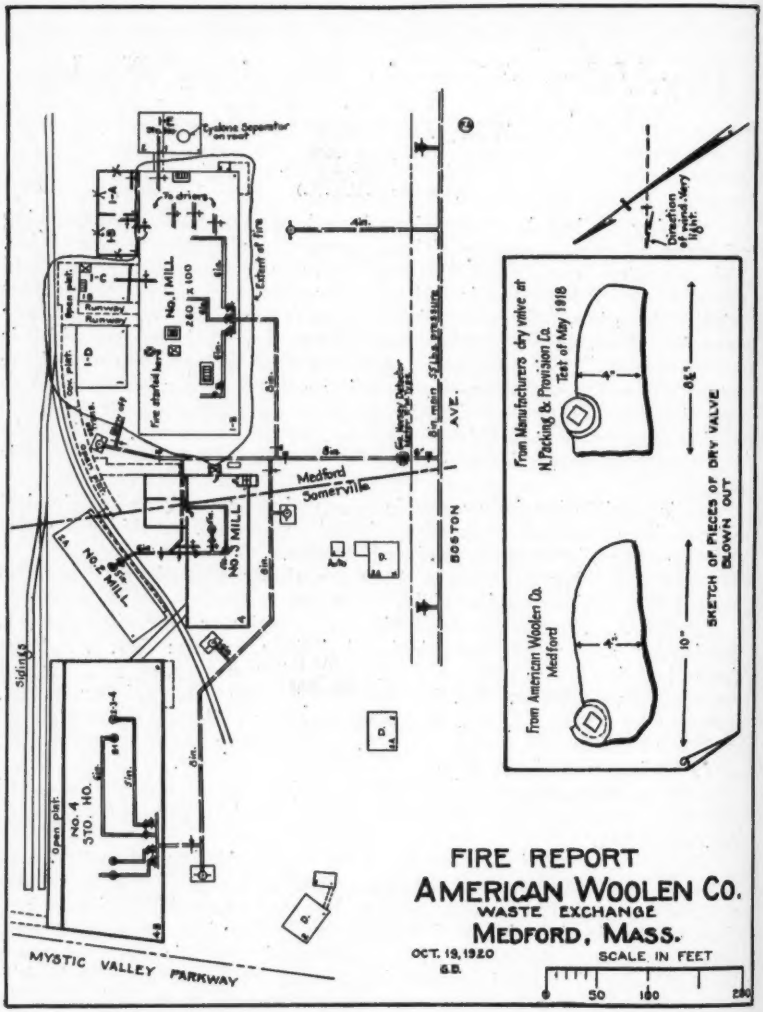
The following fire report gives a striking example of what can happen if conditions are just right.

S-28573. Shoddy Mill. This plant, which was formerly a tannery, consisted of a group of four principal buildings, namely: No. 1. A large frame building 260 x 100 feet, used for picking, sorting, carbonizing and scouring of wool waste. No. 2. A two-story frame tannery, 130 x 40 feet, occupied by tenant. No. 3. A four-story brick building, 150 x 60 feet, used for carding and storage. No. 4. A four-story fireproof storehouse, 270 x 98 feet, used for storage

These buildings were located about 40 feet apart. The total value of the plant was about $2,500,000, of which less than 10 per cent was in the No. 1 building.

The fire started in the center of the No. 1 building about 3.20 p. m. October 18, 1920, just after the pickers had shut down. The cause was probably a spark from picker lodging in gauze room, built of wire netting, located in the middle of the building. The fire spread with great rapidity owing to the nature of the stock used. As this plant lies partly in Medford and partly in Somerville, the fire departments of both cities responded, but the building was doomed before they arrived. The sprinkler system in No. 1 building was shut off early in the fire, as the sprinklers were not holding the fire, but were simply bleeding the water supply. No. 1 building and two small adjacent buildings were totally destroyed, but practically no damage was done to the other buildings, thanks greatly to the lack of wind. Loss is estimated at about $200,000.

The plant was equipped with a sprinkler system which failed to hold the fire. The system in No. 1 building was a fairly modern dry system, with sprinklers piped on 1-2-3 schedule. There were about 600 sprinklers



on the first floor of this building where fire started. These were fed through three 6-inch Manufacturers No. 3 Dry Valves, mounted side by side on an 8-inch header. The water supply was an 8-inch connection from 8-inch street main, at 55 pounds pressure. Inspectors of the Underwriters' Bureau of New England who visited the plant believe the reason for sprinklers failing to hold the fire to be primarily the breaking of one of the dry valves in the early stages of the fire. Two of the valves were running wet and the third was set dry. The fire started in the section under the protection of the third valve. After the fire a section of the

casting of one of the dry valves, about 4½ x 10 inches in size, was found blown out. Evidence seemed to show that this break occurred early in the fire, as the broken piece was covered with ashes. This break was probably caused by water hammer just after No. 3 dry valve tripped. Similar trouble has occurred before in this type of dry valve under similar conditions, and the manufacturers, realizing the possible danger, have thickened the casting on the later models. The loss of water through a break of this size would readily account for the failure of the sprinkler system to control the fire.

In addition to this, the following features would tend to make proper sprinkler control doubtful: poor construction, serious hazard and weak water supply. The building was frame construction, basement and one story in height, with a very high studded floor. The roof was peaked, sheathed underneath, there being three peaks extending the length of the building, each about twenty feet above the floor. There were no cut-offs in the building. The building contained a large amount of wool waste, partly cotton, which made possible a quick flash fire. The water supply was not sufficient to feed a large number of sprinklers, and the pressure dropped rapidly in the early stages of the fire.

The theory of the break is briefly as follows: When two or more dry valves are located on one header with one system filled with water, the tripping of a second valve will cause a sudden rush of water into the dry system. The resulting drop in pressure causes a sudden down flow of water in the first riser, which is already full of water, which closes the check valve in the dry valve casting. This sudden stopping of the flow downward creates a water hammer sufficient to break the valve casting.

This Bureau made a test about two years ago under conditions similar to those in this fire, except that the building was higher and the water pressure greater. A piece of dry valve casting was blown out from the valve running wet which is almost identical in size and shape to that blown out at the fire. The area of the hole in each case was about the equivalent of a 7-inch pipe.

This trouble has occurred in several fires with this particular type of dry valve, and might occur with other forms of mechanical dry valve where the check remains open when the water is in the system and the check does not latch. It might be prevented by putting a swinging check valve under each dry valve of the series.

While the Automatic Sprinkler Company of America state they have thickened up the casting since the trouble was first brought to their attention, there are a number of the old valves still in use connected up on headers where this trouble may occur.

In December, 1919, a fire occurred, in this same building, that opened one hundred heads, at which time it was reported that this fire, which resulted in a loss of only a few hundred dollars, "showed the possibility of a much larger loss occurring here under present arrangements." Curtain boards and other improvements were suggested, but these were never carried out.

NOTE: The manufacturers of this dry valve state that the easiest way to overcome the possible danger from water hammer is to insert a stop on the back of the check valve to prevent it from opening beyond a vertical position. This would insure the check valve remaining closed at all times (except when water is flowing into the system), and would prevent any back flow. They state the present casting, which has been in use since about 1915, will withstand 750 lbs. hydraulic pressure.

Lightning Rod Protection.

By George F. Lewis,
Deputy Fire Marshal of Ontario,
(Member N. F. P. A.)

According to the Bureau of Standards it has been estimated that not more than fifteen or twenty per cent of the buildings in the United States which are liable to damage by lightning are protected in any manner against it. The lack of protection is charged largely to swindling lightning-rod agents of thirty or forty years ago, who prospered greatly at the expense of a credulous public. Rods of every description were then erected at excessive cost to the purchaser and in most cases without much regard for the rules that should be followed in their erection.

Although a system of lightning rods appears to be a very simple affair, the element it is intended to control is not governed by simple laws; that is, laws such as might be readily understood by an artisan not specially trained in this field. Improper installation is responsible for much of the trouble which has developed in lightning rod systems, and has caused serious damage such as happened in a large barn near Orangeville, Ontario. This was rodded with the old style lightning conductor made of nine copper wires of 12 B & S gauge twisted around an iron core. The samples of rod taken from this building show how badly it was fused as a result of improper installation. I wish to draw your attention to the fact that the connections were improperly made, the rod being simply tied loosely with two or three strands of wire in some places, so that the lightning when it struck the building would obviously form an arc at the defective junction and possibly side-flash elsewhere as a result of these imperfect connections. This and similar losses could in most cases have been prevented if the plans of the system had been submitted to someone qualified to pass upon them previous to their installation; or had there been proper laws in force controlling and regulating the installation and equipment.

Losses from Lightning.

During the year 1919, there were 1,104 lightning fires in all classes of buildings, in the province of Ontario, causing a total loss of $506,907, of which $334,733 was on buildings and $172,174 on contents. Of this half million dollar loss caused by lightning, $294,129 was covered by insurance and $212,778 was a dead loss to the property owners, besides the indirect loss suffered from interruption of operations, loss of revenue and other contributing forces. Of these fires eighty occurred in the four large cities of Toronto, Hamilton, Ottawa and London, causing a total loss of $7,408, and the balance, about 93 per cent in number, are

NOTE: This article is an extract from a paper presented before the annual convention of the Fire Marshals' Association of North America, New York, December, 1920.—ED.

divided up among the 47 counties of the province. During the year there were 415 fires caused by lightning in barns and other buildings on Ontario farms, with a total loss on farm buildings, implements and produce of $401,711; the loss on buildings amounted to $248,390, and to contents $153,321. The insurance loss was $223,144, and the farmers of the province suffered a direct loss of $178,567 not covered by insurance, besides an indirect loss of many thousands of dollars more.

These figures demonstrate that over 78 per cent of the lightning losses and more than 36 per cent of the total number of lightning fires occurred on the farms of the province.

It is perhaps somewhat difficult to make the ordinary person realize the unnecessary waste of the products of the soil from fire caused, year in and year out, by lightning. I say *unnecessary waste* for it has been proved beyond peradventure that good ligtning rods properly installed are more than 99 per cent efficient.

Further analyzing our 1919 statistics for barn fires, where the loss in each case has been $300 or over, we find that there were, in this class, 102 fires caused by lightning with a total loss of $345,355; so that these 102 fires show an average loss per fire of $3,385.

The Farmer at the Mercy of the Elements.

About two years ago we distributed 190,000 copies of a booklet entitled "Fire Prevention on the Farm and Elsewhere," throughout Ontario. In this treatise I endeavored to impress upon the farmers of the province the necessity not only of fire prevention but also of adequate protection in case a fire does occur.

We, who have made a study of statistics and are familiar with the conditions, know how helpless the average farmer is when it comes to the question of fighting fire. It means in most cases if a fire starts in the farm buildings that it will burn itself out, before it can be quenched, for lack of proper fire fighting apparatus. Let me illustrate this phase of the question by the statistics I have just presented to you.

In the four large cities of the province we noted that there were 80 fires last year, caused by lightning, with an average loss of $92.50. These fires starting in congested areas were in each case potential conflagrations. The loss, however, owing to first class protection from well organized fire departments was held down to a minimum.

In the smaller cities, towns and villages of Ontario, where there was good or partial protection from fire, I find that there were 609 fires caused by lightning, which resulted in a total loss of $97,788, or an average loss per fire of $160.50. *On the farm the average loss for each fire caused by lightning last year amounted to* $714; more than seven times the loss per fire compared with the large cities and nearly five times the loss as shown by the statistics for the smaller cities, towns and villages, throughout the province. All the fires started from lightning more or less on the same basis, because the buildings were not properly protected by lightning rods; although it may be claimed, and rightly too, that barns filled with hay are more easily fired than ordinary warehouses or dwellings.

Two protected buildings were struck, and the entire loss from lightning during 1919 on buildings that were properly rodded amounted to $22.

The Mutual Fire Insurance Companies in Ontario suffered losses by lightning in 1919 amounting to $175,027, which is equal to 44 per cent of the total amount of their fires from known causes.

During the year 1918 there were 1,151 fires caused by lightning in Ontario, with a total loss of $513,145. Of these 985 were in rural districts, entailing a loss of $491,910.

The value of the farm buildings destroyed was $319,715 and the value of farm produce and other contents included in this preventable waste was $172,195. In addition to the insurance paid, the farmers whose property was destroyed by lightning suffered a direct loss of $169,733. Two rodded buildings were struck with a loss amounting to only $28.

Out of total losses of $564,127 from known causes in 1918, the amount paid by Farmers' Mutual Fire Insurance Companies in Ontario for losses caused by lightning amounted to $194,074, or 34½ per cent of the entire amount of money paid by them during the year.

In the year 1917, a total of over 1,600 lightning fires caused a loss of $660,164. In no case was the building that was struck equipped with properly installed lightning rods. From the reports of losses by fire through known causes, sustained by Mutual Fire Insurance Companies for the year, 51 per cent, or more than half, of the total amount was lost through fires caused by lightning.

There were 774 fires caused by lightning in Ontario during the first ten months of the year 1920, causing a total loss to buildings and contents amounting to $622,392.

I am indebted to Prof. W. H. Day for the information that among 40 fire insurance companies of Ontario, during a period extending over 12½ years, sixty-six and a quarter per cent of losses from fire in *barns* was due to lightning, and twenty-six and three-quarters per cent of their losses on *farm dwellings* for the same period was due to lightning. The rural claims made on these forty companies due to lightning was forty-five and a half per cent during the 12½ years.

I have endeavored to obtain reliable data and statistics regarding the waste caused by lightning fires in the United States and regret to state that it appears to be impossible to obtain this information except through the wildest guess work. A large proportion of the farm risks in the United States as well as in Canada are carried by State, county and provincial Farm Mutuals who have no central organization and probably keep no records. There are some 2,500 such companies in the States, of whom approximately ten per cent belong to the Mutual Union, and of this ten per cent, it would appear from the most reliable information I could obtain, that only about two per cent keep any records. From the source of my information I am informed that it is estimated that lightning is responsible for at least fifty per cent of their number of losses.

In the April issue of "Safeguarding America against Fire" the total losses for all classes of buildings, including dwellings, as a result of lightning fires, is given as $9,509,499 for 1918, of which nearly five million dollars occurred in dwelling houses, so that the percentage of dwelling losses to the grand total of lightning fires was 51.2 per cent. These statistics would naturally cover the business of the tariff companies only. The lightning losses for 1917, as given by the National Board, are $9,055,304.

These figures are in striking contrast to the total losses caused by incendiarism, which average, for the years 1917 and 1918, $2,800,000. The figures that I have quoted must be considered a very small proportion of the total fire waste caused by lightning which occurs every year.

With such facts as these presented to you it seems obvious that two things are essential: first, that it is absolutely necessary and provident to protect all farm dwellings, barns and other buildings with properly installed lightning rods; second, that fire insurance companies should allow a suitable discount in every case where a building is properly rodded with standard equipment.

Francis C. Moore, an author on insurance questions, in discussing "Causes of Fires," after keeping an accurate record for some ten years in the United States, says:—

> Of all farm losses, eight per cent were to live stock, caused by lightning, and eight per cent to buildings being struck, showing that sixteen per cent of all the losses are due to lightning, and that about twenty-three per cent of all the premiums (allowing for cost of adjustment) are needed to pay them—a fact generally overlooked by those underwriters who are disposed to throw in the lightning clause for nothing. With a profit ratio of five per cent (seldom secured) to give, for nothing, indemnity against a hazard which causes sixteen per cent of the losses, requires twenty-three per cent of the premiums. It is obvious that rates need to be more carefully adjusted than at present.

This naturally refers to Tariff Companies.

The Patrons Mutual Fire Insurance Association of North Western Pennsylvania a number of years ago became alarmed at the great amount of their annual losses through lightning, and as a means of reducing them approached the situation from a practical viewpoint. About ten years ago they commenced to give a reduction of 29 per cent in the assessments on policies covering rodded barns. In order to overcome prejudice against lightning rods and encourage their use, the Association purchased 11,000 feet of copper cable lightning rod and installed it on the barns of a number of its patrons at its own expense. The rods put up are inspected by a representative of the Association before the risk is accepted. No damage was paid for by the Association on these rodded buildings covering a period of five years.

The Mutual Fire Prevention Bureau of Oxford, Mich., have informed me that their statistics of losses, covering the nine year period from 1910 to 1918 inclusive, show total number of fires reported caused by lightning, 414. Total amount of loss, $725,454; and their records do not show that any of these risks were protected by a standard lightning rod equipment. They have had no losses reported from lightning where the risk was properly protected. They say: "Our experience has made us firm believers in protection against lightning. Our experience has been that the completely metal clad building, sides, roof, and cornice, with this cladding properly grounded, is practically immune from lightning.

Of 38,266 farm fires during 1918, investigated by the National Board of Fire Underwriters, 19,820, or 51 per cent, were due to lightning. All of these fires occurred in unrodded buildings. In other words, none of those farmers who had taken the precaution of installing proper lightning rod protection suffered losses from this greatest of all causes of farm fires in 1918.

Deaths from Lightning.

The United States census tables show that more than nine-tenths of the fatalities due to lightning occur in rural districts, which include all towns and villages with a population of 2,500 or less.

A fairly accurate estimate shows that over 1,800 persons are affected by lightning stroke in the course of a year in the United States and Canada, of which about one-third are killed, and the rest subjected to injuries that in a great many cases are permanent. A large proportion of this number receive their injuries in houses that are struck by lightning so that this number could be greatly reduced if the homes had been properly rodded. In the case of an unrodded dwelling being struck, sheltering a family of an average number of persons, the chances are about even that one or more of the members will be injured or killed.

Loss of Live Stock by Lightning.

The loss of live stock in fields can be reduced by grounding wire fences at least every twenty rods, though closer is better, and in barn yards or small yards where cattle are herded, at every corner. Where fences are connected with a building there should be a grounding at the first post from the building and the ground rod from the building to be connected with the fence. If the ground wires are allowed to project a few inches above the fence, strokes are prevented in the vicinity just as by the points on a building. The fence groundings should be made of the same material as the fence wires.

Thunder and Lightning the Effect of Electricity.

The first physicists who observed the zig-zag motion of the electrical spark compared it to the gleam of lightning and its crackling to the sound of thunder. But Franklin, by the aid of powerful electrical batteries, was the first to establish a complete parallelism between lightning and electricity, and in a memoir, published in 1749, he pointed out the experiments necessary to attract electricity from the clouds by means of pointed rods. The electric fluid, says he, in concluding his memoir, is attracted by points; we know not whether lightning is endowed with the same property; but, since electricity and lightning agree in all other respects, it is probable they will not differ in this; and *the experiment should be made.*

The experiment was made by Dalibard in France; and Franklin, pending the erection of a pointed rod or a spire in Philadelphia, had the happy idea of flying a kite, provided with a metal point, which could reach the higher regions of the atmosphere.

In June, 1752, during stormy weather, he flew the kite in a field near Philadelphia. The kite was flown with ordinary pack-thread, at the end of which Franklin attached a key, and to the key a silk cord, in order to insulate the apparatus; he then attached the silk cord to a tree, and having presented his hand to the key, at first he obtained no spark. He was beginning to despair of success, when, rain having fallen, the cord became a good conductor, and a spark passed. Franklin, in his letters, describes his emotion on witnessing the success of the experiment as being so great that he could not refrain from tears.

Lightning.

Lightning is an electric spark on a tremendous scale. It occurs between clouds charged with electricity more frequently than between cloud and earth. In the lower regions of the atmosphere the light emitted by the electric spark, when it shoots from cloud to cloud, is white; but in the higher and more rarefied regions it takes a violet tint, as does the spark of the electrical machine in a rarefied medium.

The effects of lightning are varied and of enormous intensity, being several millions of volts as compared with the customary 110 volts of the electric light current. The current may be in excess of 20,000 amperes in comparison with 1 or 2 amperes passing through a high power incandescent lamp. Sir Oliver Lodge calculated that the production of a lightning flash a mile long might require a difference in potential of five thousand million volts.

The lightning discharge kills men and animals, sets fire to buildings and combustible materials, melts metals, and breaks bad conductors in pieces. When lightning penetrates the ground it melts the siliceous substances on its path, and thus often produces, in the direction of the discharge, those remarkable vitrefied tubes called *fulgurites,* some of which are as much as 35 feet in length. When it strikes bars of iron it magnetizes them, and it often reverses the polarity of compass needles.

Flashes of lightning between clouds may be twenty miles in length, while the flash between the cloud and the earth is not usually more than one mile in length. They generally pass through the atmosphere in a zig-zag direction; a phenomenon ascribed to the resistance offered by the air condensed by a passage of a strong discharge. The spark then diverges from a straight line and takes the direction of least resistance. The zig-zag flashes move with extreme velocity—lasting only from one hundred-thousandth to one five-thousandth of a second—in the form of a line of fire with sharp outlines, the duration of the light of which does not amount to a thousandth of a second and which closely resembles the spark emitted by an electrical machine.

"Heat lightning" is so called because it illuminates the summer nights without the presence of any clouds above the horizon, and without producing any sound. The most probable of the many hypotheses which have been advanced to account for its origin is that which supposed it to consist of ordinary lightning flashes which strike across the clouds at such distances that the rolling thunder cannot reach the ear of the observer.

There are, further, the lightning flashes which appear in the form of balls of fire. These, which are sometimes visible for as much as ten seconds, descend from the clouds to the earth with such slowness that the eye can follow them. They often rebound like a rubber ball several times on reaching the ground; at other times they burst and explode with a noise like that of the report of cannon. This is one of the most enigmatical phenomena in atmospheric electricity, as no similar phenomenon can be experimentally produced.

One other phenomenon which I might mention in passing is the Aurora Borealis or Northern Lights. These, according to de la Rive, are due to electric discharges which take place in polar regions between the positive electricity of the atmosphere and the negative electricity of the terrestrial globe.

Lightning in general strikes from above, but ascending lightning is also sometimes observed; this may be accounted for through the fact that experiments show that at the ordinary pressure the positive electricity passes through the atmosphere more easily than negative electricity.

The law of electric attraction is "inversely as the square of the distance," consequently the discharge ought to fall first on the nearest and best conducting objects. This accounts for the fact that high buildings and those in isolated sections, as well as trees and metals, are more frequently struck. Hence, it is dangerous to stand under trees during a thunder storm, or remain in a building not protected with properly installed lightning rods of standard construction, especially if such building contains material of a highly combustible character.

Currents are induced in nearby metal fixtures or contents of a building and in conductors; and these often produce additional damage. It is probable that most of the unusual results in a lightning flash are due to these induction effects. A fire may start in flammable material between two nearly parallel wires or rods. The wires on baled hay, hay fork tracks and farm implements may thus be responsible for causing many otherwise unexplainable fires.

It is imperative, therefore, in properly rodding a building, to see that all metal parts, stationary engines and machinery are connected to the lightning rod and that they are effectively grounded.

All telephone lines in houses should be protected with a lightning arrester and also properly grounded. It is claimed that lightning will jump from ten to fifteen feet from a lightning rod to a telephone wire and vice versa.

After the passage of lightning, a peculiar odor is sometimes produced, like that noticed in a room in which an electrical machine has been worked. This odor is due to the formation of ozone, a peculiar allotropic modification of oxygen.

Return shocks are sometimes experienced, caused by the inductive action which the thunder cloud exerts on bodies placed within the sphere of its activity. These as a rule are not serious.

Thunder.

Thunder, so well known to all of us, is the violent report which accompanies lightning in stormy weather. The lightning and the thunder are always simultaneous, but an interval of seconds is always observed between the perception of these two phenomena, which arises from the fact that sound only travels at the rate of about 1,100 feet in a second, while the passage of light is almost instantaneous. Hence you will only hear the noise of thunder five or six seconds after the lightning, according as the distance of the thunder cloud is five or six times eleven hundred feet. The noise of thunder arises from the disturbance which the electric discharge produces in the air. The echoes sent between the clouds and the earth, or between objects on the earth's surface may to some extent explain the prolonged rolling of the thunder, and its strange rising and falling. A person in the immediate neighborhood of a flash of lightning hears only one sharp report which is peculiarly sharp when an object is struck by it. A person at a distance hears the same report as a prolonged peal, and persons in different situations hear it each in a different way.

The rise and fall are not continuous for the whole peal appears to be made up of several successive peals, which rise and fall as the whole. Some authorities account for this modulation by the forked form of the lightning, which makes so many different centers of sound, at different angles with each other, the waves coming from which interfere with each other, at one time moving in opposite directions and obliterating the sounds, at another in the same way, and then strengthening the sound produced by each.

Thunder has never been heard more than fourteen miles from the flash. The report of artillery has been heard more than one hundred miles from the battlefield.

You have no doubt often observed that a strong upward current of air is one of the most conspicuous features of a thunder storm. Picture to yourself the whirlwind preceding many a thunder storm you have experienced. Trees are uprooted, branches are broken off, leaves and papers are swept over house tops.

You can imagine this thunder storm as a great inverted funnel with the warm ascending air and the cold descending air swirling in a great vortex; and if we could but visualize a cross section of this thunder storm we would see the dust cloud, the squall cloud, the storm collar, the hail, the thunder heads, the primary rain, due to initial convection, and the secondary rain, which according to meteorologists is a thing of frequent occurrence and often is due to the coalescence and quiet settling of drops from an abandoned portion of the cumulus cloud in which and below which winds and convection (the diffusion of heat through the air by motion of its particles) are no longer active.

Experiment shows that it requires approximately a velocity of eighteen miles an hour for the air to support the larger drops and even a greater velocity to support the average hail stone. It must therefore be inferred that an up-draft of about one-third of a gale of wind (a gale blows sixty miles an hour) must often occur within the body of the storm.

Experiment also shows that rain cannot fall through air of ordinary density whose upward velocity is greater than about eighteen miles an hour, or itself fall with greater velocity through still air. With such a current, or with such a velocity, drops large enough if kept intact to force their way down because of the action of gravity, do not attain a greater velocity than eighteen miles an hour with reference to the air, but are *so blown to pieces* that the increased ratio of supporting area to total mass causes the resultant spray to be carried aloft together with all original smaller drops. It would therefore be apparent that the updrafts within a cumulus cloud frequently must break up at about innumerable drops the same level which through coalescence have grown beyond the critical size, and thereby, according to Simpson's experiments, produce electrical separation within the cloud itself.

The choppy surges and pulses of the turmoil of a thunder storm compel mechanical contact between the drops, whereupon the charges break down the surface tension and insure coalescence. Hence, once started, the electricity of a thunder storm rapidly grows to a considerable maximum.

After a time the larger drops reach, here and there, places below which the updraft is small—as we can understand that the air cannot be

rushing up everywhere—and then *fall as positively charged rain,* because of the processes just explained.

The negative electrons—the smallest known component of matter, always associated with an unvarying unit charge of negative electricity—in the meantime are carried up into the higher portions of the cumulus clouds, where they unite with the cloud particles and thereby facilitate their coalescence into *negatively charged drops.* Hence, the heavy rain of a thunder storm should be positively charged, which also usually is the case.

Such in brief is Dr. Simpson's theory of the origin of the electricity in thunder storms, a theory that fully accounts for the facts of observation and in turn is itself abundantly supported by laboratory tests and experiments. These conclusions are further borne out from observations and graphic descriptions of balloonists who have experienced the trying ordeal of passing through the heart of a thunder storm; it is known that there is violent, vertical motion and much turbulence in the middle of a large cumulus cloud.

The Earth is Charged with Negative Electricity.

From observation and experiment the interesting conclusion is drawn in regard to normal atmospheric electricity that the earth everywhere, land and water, and from pole to pole, is a negatively charged sphere of practically constant surface density, surrounded by an atmosphere so conducting that it is constantly carrying away a current that amounts on the whole to about one thousand amperes.

Where the supply of negative electricity comes from that keeps the surface of the earth on the whole negatively charged in spite of this steady, great loss, or how the outgoing current is compensated, no one knows.

Rain does not help matters, for it has been demonstrated by Simpson that while the electricity brought down by the rain was sometimes positive and sometimes negative, that the total quantity of positive electricity brought down by the rain was 3.2 times greater than the total quantity of negative electricity.

Neither, so far as known, is compensation supplied by means of the lightning, for, in the great majority of cases, this, too, is positive from cloud to earth. And so the puzzle remains.

As Simpson put it: "A flow of negative electricity takes place from the surface of the whole globe into the atmosphere above it and this necessitates a return current of more than one thousand amperes; yet not the slightest indication of any such current has so far been found, and no satisfactory explanation for its absence has been given."

This shows that, contrary to opinions often advanced, there is no obvious and close relation between the thunder storm and normal atmospheric electricity, but that they are distinct and independent phenomena.

Thunder storms usually occur wherever there is a rapidly rising current of moisture laden air.

Thunder showers occur in nearly all parts of the world, but the number decreases from the equator towards the pole. In some sections of the North American continent, such as California, Wyoming and

British Columbia, fires from lightning are practically unknown. This situation varies, with an average of from thirty to sixty days, in which thunder storms occur in different parts of the United States and Canada, with a maximum number in the Easterly Gulf States. Thunder storms may occur in any month of the year, but they are most frequent during the hot period of the summer months.

The Theory of Origin of Thunder Storm Electricity.

A knowledge or at least a good working theory of how the great amount of electricity incident to thunder storms is generated, is absolutely essential to their logical explanation so that we may have a clear understanding of the probable inter-relations between their many phenomena. Fortunately, such a theory, as it is abundantly supported by observations and by laboratory experiments, is available as a result of work done on this subject in India by Dr. G. C. Simpson of the Indian Meteorological Department, who has made a number of well devised experiments to determine the electrical effects of each obvious process that takes place in the thunder storm.

Freezing and thawing, air friction and other things were tried, but none produced any electrification. Finally, on allowing drops of distilled water to fall through a vertical blast of air of sufficient strength to produce some spray, actual results were developed showing that breaking of drops of water is accompanied by the production of both positive and negative ions and that three times as many negative ions as positive ions are released.

The Lightning Rod Conductor.

The principle of the lightning conductor is, that electricity selects the better of two conducting paths, and that, when it has a path of sufficient conductivity, it is disarmed of all destructive energy. The lightning rod was invented by Franklin in 1755. Scientists generally have since then advocated the need of the protection of houses, barns and other property against destruction by lightning. Experience has proved that equipment is now available at a small outlay which would insure ninety-nine per cent protection to the lives and property of our people, when properly installed. Without elaborating on this particular point, let me draw your attention, for the purpose of further discussion, to the fact that there are few, if any, useful or mechanical devices in this world which will develop ninety-nine per cent efficiency. By comparing it with other familiar mechanical devices, we are forcibly impressed with the wonderful efficiency of the lightning rod.

To make the lightning rod one hundred per cent efficient it would be necessary to protect a building with a net work of conductors resembling a bird-cage and the large additional expense which such a system would entail is not considered warranted in comparison with the almost negligible loss sustained on properly rodded buildings of standard equipment, throughout this continent, as shown by most reliable statistics.

Like the prevailing winds common in various parts of the country, we find that in the province of Ontario the prevailing direction of thunder storms is from Northwest and Southwest. With this knowledge it is an easy matter to properly protect a building.

As the action of a lightning conductor depends on induction and the power of points, which we have already demonstrated to you, Franklin, as soon as he had established the identity of lightning and electricity, assumed that lightning conductors withdrew electricity from the clouds. *The opposite is the case.*

When a storm cloud, positively electrified, rises in the atmosphere, it acts inductively on the earth, repels the positive and attracts the negative fluid, which accumulates in bodies placed on the surface of the soil and the more abundantly as these bodies are at a greater height.

The tension is then greatest on the highest bodies which are therefore most exposed to the electric discharge; but if these bodies are provided with copper points, such as are used on lightning conductors, the negative electricity, withdrawn from the ground by the influence of the cloud, flows into the atmosphere, and neutralizes the positive electricity of the cloud. Hence, not only does the lightning conductor tend to prevent the accumulation of electricity on the surface of the earth, but it also tends to restore the clouds to their natural state, both of which actions concur in preventing lightning discharges. This is the manner in which the action of lightning conductors comes most frequently into play.

Owing to the high potential the lightning conductor is sometimes inadequate to discharge the ground, and the lightning strikes; but the conductor receives the discharge, in consequence of its greater conductivity, and the building is preserved.

Lightning conductors may be divided into three parts: (1) the point or part overtopping the building; (2) the conductor or part connecting the points with the ground, and (3) the part in the ground.

I believe, after careful research and practical study of this important question, that we should be able to establish as a standard for all lightning conductors pure soft drawn copper in the form of a flexible cable of either flat or round construction of the rope lay, loose twist, or braided types without a supporting core. The weight should be not less than three ounces per foot or 187.5 pounds per thousand feet in length. Individual wires of the cable to be not less than number seventeen B & S gauge in size or 0.045 inches in diameter.

The exposed surface area of such copper cable should be not less than three square inches for each linear inch of the lightning rod conductor.

Where the structure to be protected is from 60 feet to 150 feet in height, the capacity of the protective system should be double that of the standard 3 ounce copper cable; and for structures over 150 feet in height the capacity should be treble the standard 3 ounce cable. This increased capacity may be obtained either by increasing the number of down cables or by using heavier cables, with additional number of points, according to the design of the structure.

Couplings, connectors, fasteners, supports, air terminal rods and points should comply with the general specifications for copper rods as laid down by the Underwriters Laboratories' standard for the construction and installation of lightning equipment.

I advocate the adoption of copper as the metal to be used in standard lightning rods on account of its strength, its high electric conductivity and its great resistance to atmospheric and soil corrosion.

Ground Terminals.

Ground terminals are the devices by means of which electrical contact is made between the lightning conductor equipment and the earth and are intended to provide a low resistance path from the air terminals to the earth.

As the efficiency of a lightning conductor equipment is primarily dependent upon the thoroughness with which it is brought into contact with permanently moist earth, the base of each conductor is required to be grounded in a standard manner.

1. By connecting the conductor to underground metallic water piping at a point outside of building.
2. Where sufficient depth of earth and requisite moisture cannot be obtained, by connecting the conductor to ground plates or other standard grounding devices sufficiently deep to provide ample capacity, through a system of low resistance conductors, for the distribution of the electrical charge.
3. By extending the base of the rod down into permanently moist earth.

Method No. 1 is recommended in all cases where possible and the specifications of the N. F. P. A. and of the Underwriters' Laboratories prescribe that when groundings are made as described in No. 2 and No. 3 they should extend into the earth at least eight feet. After giving this matter due consideration I am lead to believe that the minimum depth of such groundings should be *ten feet*.

In the majority of cases, especially in the country, dwellings and barns are built on a knoll or high ground for the obvious purpose of providing good natural drainage, and for this reason, while the ground may be fairly moist in the spring and early summer, it is very liable to be thoroughly dried out by the time the hot summer months arrive and at the season when thunder storms are most frequent.

Construction.

Without going into details of installation I would like to impress upon your minds the necessity of one or two fundamentals. All parts of the conducting rod should be properly connected either by tight joints, by riveting or soldering or both. The utmost care should be taken that there is no break in the conduction, and the rods should be properly protected for a distance of eight or ten feet from the ground up. No sharp turns should be made in the conductor, each bend being made as round as possible.

Rods are subject to the action of the elements, wind, snow and ice, thermal expansion and contraction, and in the event of a stroke of lightning, to electromagnetic strain; joints should be as few as possible, the tendency to pull them apart and loosen fastenings are very severe, and as a rod is expected to be efficient for many years without any attention, unusual precautions are necessary to guard it against injury. Copper cable should not be insulated, nor attached to wooden buildings with galvanized iron nails, or with copper strap fasteners secured with iron nails. In a short time any iron fastening will corrode away and allow the cable to come loose from the structure.

Joints and couplings in lightning rods must remain in secure electrical contact, and not easily be pulled apart or loosened by vibration. With the exception of copper and lead, in constructing a lightning rod, contact between metals which occupy different positions in the electromotive series should, in general, be avoided.

European Development of the Lightning Rod.

In Europe the lightning rod was not brought into discredit during the early part of its history to the extent that it was in the United States and Canada, and as a consequence, the European public seem to regard it in a more serious light than do the peoples of these countries. During the century or more that it has been in use in European countries, its performance has been subjected to analysis a great many times, and it seems that if it were not entirely satisfactory, or not even an economical way of insurance against lightning, it would have been discarded many years ago. On the contrary, European governments and scientific societies have given much more attention to the subject of protection against lightning than has heretofore been given under the auspices of what we like to think as being our more progressive governments, of the North American continent.

The principal results of the work of the Lightning and Research Committee of England have been the formulation of a set of rules regarding the installation of lightning conductors and the pointing out of the causes of failure of lightning conductors to perform properly where protected buildings have been struck and damaged.

France, Austria, Holland and Germany have also given a considerable amount of official attention to the protection of public buildings against lightning. School authorities insist upon having lightning rods on all school houses and in many cities annual appropriations are made for the specific purpose of keeping the lightning rods on public buildings in repair.

Legislation.

Of the forty-eight States of the Union there are only two—Maine and New Hampshire—which have enacted legislation licensing and controlling the manufacture and sale of lightning rods.

Various other States have passed laws affecting the sale of lightning rods, but generally speaking, such legislation has been enacted for the purpose of revenue. Texas, for instance, has a law in effect whereby every person dealing in lightning rods pays an annual tax of $36.00 to the State and $18 to the county. Every person canvassing for the sale of lightning rods pays an annual tax of $100 to the State and $50 tax to the county, in each county in which such canvassing is done.

The law in North Carolina necessitates every person, firm or corporation selling and erecting lightning rods to pay an annual license tax to the Insurance Commissioner of $50 and also eighty cents on every $100 received from the sale of lightning rods before receiving a license on July 1st of each year. A penalty of $100 is the chance a person takes for making a false statement. An unlimited number of agents are permitted by paying a fee of $1.00 and the county in which the applicant does business may charge a tax of $5. A limit of $20 is placed on any county,

city or town in levying tax on a dealer for selling from any receiving point. The Insurance Commissioner is authorized to issue a license upon satisfactory evidence that the brand or make of lightning rods are standard and efficient when properly erected.

In Virginia a merchant must pay $25.00 license fee for handling or selling lightning rods.

That, in short, is the extent of the legislation controlling this important industry on the entire North American continent; for Canada, nor any of her provinces has yet placed lightning rod legislation on their statute books. However, we have great expectations and hope that at the next session of the Ontario Legislature, which will be called together about the middle of January, 1921, that the government will introduce and pass legislation of an up-to-date and constructive character. The Ontario Fire Prevention League, which is in affiliation with the Fire Marshal's office, has actively prosecuted a movement towards the education of the public mind, so that such legislation may be understood and generally accepted. I submit as an appendix a draft of the proposed Act.

This bill, known as "The Lightning Rod Act," provides that material or apparatus intended to be used for the protection of buildings from damage by lightning shall not be sold except under authority of a license from the Fire Marshal, and requires as a preliminary to the issuance of a license the filing of a bond for $10,000 as security for the payment of judgments recovered against manufacturers for non-compliance with the provisions of the Act or the regulations, as provided for in the "Guarantee" agreement given when the rods are installed.

The Act makes provision for the licensing of agents, and produces an income through a system of fees and taxation, which it is purposed shall be used for the administration of the Act and placing in the field qualified inspectors who will be capable of advising on questions of defective rods and installation, installed heretofore, and checking up new installations to see that they comply with the Act and the regulations.

In conclusion, let me sum up the whole matter by saying that the cumulative evidence collected, the surface of which we have barely scratched, appears to be entirely favorable to the lightning rod as a protective device, and gains added significance from the fact that no contrary evidence or opinions are successfully brought forward. No place to which a person may ordinarily retire can be considered absolutely safe from lightning. The place of greatest safety for man and beast as well as for our material assets is a well-rodded building.

May I suggest, that in considering the programme for the coming year, in States where lightning fires are frequent, this would be a desirable matter for every Fire Marshal to take up and carry through to a successful issue. If it were possible for us to carry through effectively one piece of important legislation such as this every year, the annual fire waste of this continent would gradually but none the less very materially be reduced to the extent of many millions of dollars within the next decade.

An Analysis of Where Fires Start in Schools, Institutions and Hotels.

By Henry A. Fiske,

(Member N. F. P. A.).

A short time ago the writer made an investigation of National Fire Protection Association Fire Reports covering the above-mentioned classes of property.

This investigation was chiefly for the purpose of determining where fires start in these properties, and while some information was also secured as to the cause of fire, the following report has reference only to the location or portion of the building in which the fire starts.

The primary reason for securing this information was to get some idea of what proportion of the fires would be controlled or extinguished if automatic sprinklers were placed in certain portions of these buildings, such as basements and working portions.

While it is recognized by everyone that in order to make properties wholly safe it is necessary to place automatic sprinklers throughout all portions, nevertheless the expense of such an automatic system has prevented the general introduction of sprinklers in these classes and similar properties where the property value (buildings and contents) is relatively small, and the insurance rates without sprinklers less than many other classes of property, such as most manufacturing and mercantile properties.

Partial equipments of automatic sprinklers have been installed in some of these properties, but there seems to be no definite idea as to the protection afforded, partly because we do not seem to have any information as to where fires start.

It is to be regretted that the N. F. P. A. reports of fires on the above classes of property are relatively few, for these reports are usually quite complete and much more satisfactory than most other fire reports. The number of reports is, however, sufficient to give a rough idea as to where fires start. So far as the writer is aware, this is the first authentic information on this particular subject.

The following table shows the number of fires occurring in different portions of the three general classes of property, namely:

1. Schools and Colleges.
2. Institutions, which includes hospitals, sanitariums, asylums, and similar properties.
3. Hotels, which also includes season hotels.

The location where fire occurs is divided as follows:

1. Basement, which includes all portions of the basement, including Boiler and Engine Rooms, Storerooms, etc., if located in basement.
2. Working portions, which does not include any basement fires, but does include Boiler and Engine Rooms (if not located in basement), Work Rooms or Work Shops, Kitchen, Laundry, Laboratory, Storage, Attics.
3. Roof or exposure fires. This includes all fires which come from the outside or which start on the outside of the roof from sparks or other causes.
4. Fires starting in other portions of the property that are not included in Nos. 1, 2 or 3.
5. This gives the total number of fires where there was sufficient information to determine in what portion of the building the fire starts.
6. This gives the number of fires where the location of the fire is unknown.

In each case the table gives the number of fires in each locality and the percentage which this number bears to the total number of fires where the location is known. The number of fires and percentages are also given for Nos. 1 and 2 together.

Location of Start of Fire	Schools & Colleges		Institutions		Hotels	
	No. of Fires	% of known Fires	No. of Fires	% of known Fires	No. of Fires	% of known Fires
1. Basement	21	28	4	14	28	18
2. Working Portions	25	33	14	48	75	47
1 and 2 together.....	46	61	18	62	103	65
3. Roof or Exposure	8	11	2	7	15	9
4. Elsewhere	20	27	9	31	43	27
5. Total Known	74		29		161	
6. Unknown	16		6		14	

As regards basement fires, it will be noted that over one-quarter of the fires in schools are in the basement, but only about 15 per cent in the other two classes. This seems reasonable, because the working portions are relatively less important in schools than in hotels or institutions. Almost half of the fires in institutions and hotels are in the working portions. When we combine the fires in basements with those in working portions, all three classes are about the same, namely, from 60-65 per cent. This would tend to show that more than half of the fires in these classes start either in the basement or the working portions.

From the standpoint of property loss, it would therefore seem that an equipment of automatic sprinklers throughout the basement and working portions should reduce the fire loss in these properties at least one-half. It is quite possible that the reduction in fire loss might be considerably more than this, as fires in the basement, for instance, are apt to be more serious and cause greater losses than those that start on the upper floors.

If we consider the question of safety to life, the value of sprinklers

in basement and working portions is probably greater than for property damage, for the fires which start in these portions are more likely to spread before the inmates have a chance to escape than if the fire starts in living rooms or class rooms, for instance.

If it is a fact that 60 per cent of the fires in these classes start in the basement or working portions, it is likely that from the standpoint of safety to life the danger is reduced from 70-80 per cent if automatic sprinklers are installed in these portions. Furthermore, if we extend the sprinklers to hallways, stairways and elevators, which can be done with relatively little additional expense, the danger of loss of life by fire will be still further reduced and largely eliminated.

Houston Hotel Fire and Conflagration,

Klamath Falls, Oregon.

Report by H. H. Pomeroy and Gilbert W. Allen.

(Members N. F. P. A.)

Nine or ten persons lost their lives and five others were seriously injured in the fire which destroyed the Houston Hotel and other buildings in Klamath Falls, Oregon, at three o'clock in the morning of September 6, 1920. The building had been long considered a fire trap. Reports of its danger had been ignored by the city authorities. Fire escapes, extinguishers and even proper exit signs were lacking. The fire department was small and inefficient and the water supply inadequate.

The lessons of this fire have a universal application, and should by no means be considered as applying only to this particular conflagration at Klamath Falls, Oregon. Conditions such as existed in Klamath Falls undoubtedly exist today in many cities in the United States and Canada. They will be known and reported, but deliberately ignored, as they were in Klamath Falls, until a catastrophe comes to shock people into a realization of their criminal negligence.

The report of the Houston Hotel fire and Klamath Falls conflagration, because so typical of the way in which deplorable conditions are ordinarily disregarded, and because it gives so many valuable lessons, is printed below in full, without comment except to emphasize by italics some of the particularly salient points. This is the official report, submitted to Hon. A. C. Barber, Oregon State Fire Marshal (member N. F. P. A.), by Chief Deputy State Fire Marshal H. H. Pomeroy and Deputy State Fire Marshal Gilbert W. Allen, and is based on an official investigation made by them subsequent to the fire. (The several references to appended matter refer to transcripts of testimony at the coroner's inquest and other data bearing on the fire. This additional information forms the basis of this report, but because of its large volume is not reproduced here.)

Report on Houston Hotel Fire and Conflagration, Klamath Falls, Oregon.

Acting under the provisions of the State Fire Marshal Law and the direct request of the Executive Department, which latter was prompted by a telegraphic appeal from Mayor I. R. Struble and City Health Officer Dr. A. A. Soule, of Klamath Falls, we, your deputies who conducted an official inquiry into the cause and results of the fire which occurred at Klamath Falls on the morning of Monday, September 6, 1920, beg to report our findings and conclusions as follows

Findings of Fact.

The fire started at the Houston Hotel, Second and Main Streets, at about 3.17 o'clock on the morning of September 6th, and so rapid was its spread that it assumed the proportions of a conflagration, in consequence of which nine (possibly ten) persons lost their lives; five others were seriously injured, and the Houston Hotel and nine other public buildings and dwellings were destroyed. The loss of property is estimated at approximately $100,000.

The list of persons who were burned to death, some of them charred and dismembered beyond the hope of positive identification—those burned and badly injured, and the list of property destroyed are set forth in the newspapers, extracts from which are submitted herewith (not reproduced).

Cause of Conflagration.

The indications are that the fire started in the rear of the Houston Hotel, evidently from rubbish that was known to have existed there from time to time, but just how it originated is at present a mystery and, perhaps, may never be known. Whether it could have been prevented by judicious legislative safeguards or, after having started, it could have been subdued before it had exacted such terrible toll of death and property loss may best be judged by the transcript of testimony taken at the coroner's inquest and our private hearing, which are hereto appended and form the basis of these deductions.

The Houston Hotel, a three-story frame structure, owned by Z. G. Harris and lately tenanted by Mrs. Goldie Houston, has *long been known as a veritable fire trap, altogether without facilities or furnishings in the nature of fire protection, prevention or escape*—even without exit signs in its numerous hallways or any kind of signs whatsoever in the entire structure, except one in the office, which, according to the testimony of one of the seriously burned victims, who told his story between agonized groans in his hospital bed, exhorted the patrons to "Pay in Advance." There were some knotted ropes dangling from the third story front balcony railing which masqueraded as *emergency fire escapes,* but they were known to have been so utterly *rotten and unsafe* that when the emergency arose none of the panic-stricken tenants would trust them.

The building was three stories front and two back, having been constructed on sloping ground. It contained about 50 rooms, 40 of which were furnished and rented singly, while there were six apartments besides office and parlors on the ground floor. On the fatal night preceding a big Labor Day celebration, every room was occupied, some with two or

more occupants, while four cots were provided and all occupied in the office. Some of the regular tenants conducted light housekeeping in the rooms and apartments.

Should Have Been Condemned.

According to the report of your deputies, G. W. Allen and George W. Stokes, who made an official survey of Klamath Falls in September, 1919, at the request of Mayor Struble, a copy of which is now on file in your department, it was a dilapidated and dangerous affair, and should have been condemned and razed long ago in the estimation of the present and former fire chiefs of Klamath Falls, both of whom declare they would have condemned it had they been clothed with proper authority. The *chimneys were supported by brackets,* and some of the stoves and flues were in extremely dangerous condition, *electric wiring bad,* and there was *but one (dry) fire extinguisher in the entire building,* and many other outstanding features which, in the estimation of your deputies, as well as many citizens of Klamath Falls, constituted it a menace to the lives it contained, as well as to the community.

The contents of a previous report by Deputies Allen and Stokes were well known to the Mayor, City Council, Fire Chief and other officials, copies having been furnished them, together with recommendations for the elimination of many designated hazards, including the Houston Hotel and many other structures in the city regarded as extreme hazards, and the most of which *still exist* (at the time of our investigation) without remedy. A series of drafts of model ordinances designed to correct and eliminate many of the fire hazards of the city and giving city officials authority to inspect properties and correct the evils found to exist were furnished the City Council of Klamath Falls.

Report Ignored — Ordinances Tabled.

This survey report, read in open Council, was summarily dismissed by the "placed on file" route. The ordinances, one designed to regulate the storage of gasoline, another regulating the conduct of garages, another regulating the interior construction of motion picture theatres and providing safe exits, and still another defining what constituted unusual fire hazards and providing for inspections and authorizing condemnations in extreme instances, never got beyond first or second reading, and all suffered the ignominy of being "tabled." Each in turn ran up against objections and criticisms from interests directly affected, which was sufficient for its end. The city attorney was instructed to draft ordinances covering these protective features which would be satisfactory to all concerned, but they have never materialized.

There is but one ordinance on the Klamath Falls statutes authorizing fire inspections by the Fire Chief and the elimination of fire hazards, but all cases of infractions must first be reported to the Mayor and City Council, and in no case is the Fire Chief permitted to take action without authority from these official sources. Cases on record are cited in which the fire chief has reported hazards to the Mayor without result, and in one particular case chronicled in the testimony of Fire Chief Keith Ambrose, appended hereto, in which he reported a particularly extreme hazard two or three times to the Mayor, only to receive the final orders to *"leave it alone."*

The Mayor and certain other officials of Klamath Falls showed a disposition to be resentful of and antagonistic toward the State Fire Marshal's Department for the exercise of its good offices and legal functions in the promotion of fire prevention and protective measures, and have assumed the attitude that the government of Klamath Falls is competent to take care of its interests without outside interference.

To substantiate the above, we quote a paragraph from a typewritten communication, dated January 23, 1920, to the State Fire Marshal, written on the official stationery of the city attorney of Klamath Falls, and signed I. R. Struble, Mayor:

"Personally, I fail to understand how the Fire Marshal's office can assume jurisdiction over a matter of this sort, as this city is a self-governing community, and the people elect its officers to use their judgment in the government of the city. They should be more competent to know who are qualified to act as officials of the city than someone who probably has never seen the city in his life, or who does not live here."

Facilities Grossly Deficient.

When the Houston Hotel fire broke out there were *only three persons on duty at the Fire Department,* to wit: Fire Chief Keith Ambrose and two volunteer firemen. Assistant Fire Chief Mark Howard, the only other paid fireman, was away on his vacation. The sole fire-fighting equipment available for combating the blaze was a triple combination, motor-driven truck, the capacity of which is 350 gallons per minute, and about 3,000 feet of hose, 1,500 feet of which was of comparatively recent purchase. The fire chief is also driver of the truck. He drove the engine to the nearest hydrant from the fire, where the two volunteers alighted and strung the first line of hose, and then drove on and strung the second and third lines alone. About this time Sheriff Humphrey and one or two other citizens arrived to render assistance.

Competent witnesses, including the man who drives the street cleaning apparatus and the night patrolman, who were among the first to have been apprised of the fire, testified at the inquest and at our inquiry that it required from *fifteen to seventeen minutes to get the alarm through central* to the department. The night telephone operator says that the call was received and put through with dispatch. The fire was discovered at 3.17, and the alarm was not received at the department until 3.35, according to testimony. Certain it is that the department was late in arriving upon the scene, and the fire had gained much headway.

Water Pressure Fails.

The water pressure during the early stages of the fire was very low. Had it been adequate or up to standard Fire Chief Ambrose is confident that he could have confined the blaze to the hotel at least, and saved all of the other buildings destroyed, and possibly could have saved the lives of some of the innocent victims. During the first few minutes of the play of the first line of hose there was fair pressure, all agree, but the pressure went off, some say, for a period of from ten to fifteen minutes, during which interval the heat became so intense that the fire fighters were forced to give ground. Several residents in the same block could get no water from their garden hose. One man could not get enough water in his house to cleanse his false teeth.

Water system officials account for this serious deficiency in the face of such an emergency, when the first few minutes means the winning or losing of a battle against the fire fiend, as being due to the crossing of wires and shutting off of the current to the auxiliary pumper which supplies water directly into the mains. It was also admitted that *one of the three reservoirs* which supplies the city *was shut while undergoing repairs.* The water mains throughout the city are small and not at all in proportion to the growth and needs of the community. The pressure, at best, was not equal to the demand.

Conclusions and Recommendations.

In view of the foregoing facts, deduced from the evidence submitted at the hearings, interviews with prominent citizens and other information gathered during our investigation, we are led to the following conclusions, and to the correction of the errors and evils as pointed out in these conclusions we most respectfully submit as our recommendations:

The fire started from some unknown cause in rubbish at the rear of the Houston Hotel.

The Fire Department is utterly lacking and sorely deficient in mechanical and other fire-fighting apparatus and equipment, and the manpower is far too low for a community of the size. (As a result of the fire, some extra men have been put on the fire-fighting force—at least temporarily.)

The water system, especially the mains in the business section, is wholly inadequate, as was evidenced by the failure of the pressure when put to the crucial test. The mains are those originally installed for the small town of a few hundred people, and their capacity is not at all in keeping with the industrial and population growth of the city.

The fire alarm system is not in keeping with the community of Klamath Falls and its rapidly developing proportions and responsibilities.

The city is deplorably lacking in fire prevention and protection ordinances, and sadly in need of legislation to cure the evils which exist at present and have been permitted to exist for more than a year past, and to clothe the fire chief with ample inspection and enforcement authority without being handicapped and hindered by petty political and factional strife and jealousies.

"Somebody Is Responsible."

The officials who shape the political destiny of Klamath Falls, from the mayor down, are men of sterling worth and unimpeachable character, so far as the results of our investigation disclosed. The great trouble seems to be that they are too easy-going—of the "it never has happened and, therefore, it never will happen" sort. They feel and appreciate their duties and responsibilities keenly; their motives are unquestioned, and their openly avowed ambition to clean up and rid their proud city of its deadly menaces may be sincere, but they seem to lack the courage of their convictions. They shrink from hurting anyone's business or feelings, and their courage crumbles and fails before the least criticism or opposition until they have come, by force of habit, to choose the course of least resistance.

The citizenship of Klamath Falls, too, is of the highest order of God fearing and God loving people. There is not a man or woman en-

dowed with ordinary powers of observation and reasoning but is and had been aware of the dangerous conditions that have been threatening their community and home-life for many months. They, like the peoples of other communities, are so thoroughly imbued with the love of peace, harmony and prosperity that they dread the discordant agitation for betterment of civic conditions. Most everyone is "too busy making money" and having a good time to lend ear to the calamitous harpings for civic reforms. "Retrenchment in governmental affairs" along the line of cutting down budgets and lowering taxes is far more musical and harmonious.

Chief of Fire Department Ambrose is particularly qualified for the position of chief, and is greatly interested in fire prevention and inspection work, and if given the 100 per cent co-operation by the city officials it is only reasonable to presume that the fire waste in Klamath Falls could be reduced at least 50 per cent, and possibly more.

Too Much "Passing the Buck."

The Mayor "passes the buck" to the Council and the Council passes it on to the people. Klamath Falls, however, has learned her lesson in the hard school of experience, heartrending and regrettable though it has been, of the frightful cost of lethargic indifference and dallying with the serious problem of civic improvement along preventive and protective lines, and we feel sure—at least we sincerely hope—that those precious lives have not been sacrificed in vain.

We do not feel competent or called upon to place the blame for this terrible calamity. Nobody is willing to assume the blame or responsibility for the disaster personally, nor to point the finger of accusation toward any individual or group of persons. Yet, in the language of one of the leading members of the Klamath Falls clergy who delivered an eloquent sermon upon the occasion of the public and joint memorial service, held in respect to the victims whose innocent lives were sacrificed upon the altar of carelessness:

"Someone is responsible for this tragedy. Responsible to God, to the nation for the loss of its citizens, to the State and to the city, and, most of all, to the relatives of these victims. We are disgraced in the eyes of the whole State. We are branded as a community where the law is not enforced, and we are sunk low in our neighbor's esteem. Let us admit our humiliation frankly and correct it by sincere reform."

Fire Prevention in Dry Cleaning Plants.

By E. J. Smith.*

(Member N. F. P. A.)

The subject of fire prevention as applied to dry cleaning plants is one which is worthy of considerable study, and it would be possible to prepare extensive articles on some of the sections of which in a general talk only brief mention may be made. This is particularly true if we are permitted to interpret fire prevention in its broadest sense, and include protection as well. As a means of condensing a subject which otherwise might be expanded to the continued-story class, we will give no more than passing attention to features which may be classed as common to all plants employing machinery or processes involving the possibility of relatively high temperatures.

In thus passing over the general hazards common to many manufacturing processes, do not fall into the error of belittling the possibility of fires being started, or considerably augmented, by improperly installed equipment, failure to observe the rules of good housekeeping or the lack of constant attention to the proper maintenance of the equipment. Shafting and machine bearings must be lined up and the methods employed to lubricate the bearings must be such as to insure against overheating, and at the same time not so generous as to cover walls, floors and ceilings with oil. We frequently hear of fires caused by hot bearings, and know that oil-soaked material often provides the necessary link to carry on the effect of the overheated bearings. The question of good housekeeping must never be neglected, even though you may get as tired of the job as the housewife. Keep aisles clear; it is possible that you may need to get out in a hurry some day. Do not allow dust to accumulate even in places where it may not be seen—some day you may find that dust is more vicious than most of us realize, and certainly if in any of your processes organic dust, or for that matter inorganic dust, is produced in any material quantities, it would be well to avoid all possibility of ignition and arrange a collecting system, which will convey the dust away from the point at which it is produced. Dust suspended in the air in proper proportion may be as dangerous as gasoline. Keep all steam pipes away from combustible material, and do not allow paper, rubbish or anything that will burn to accumulate on steam pipes or radiators. Remember that wood kept in contact with steam pipes will char, and it is agreed that fires have been caused by the charring of wood by even low pressure steam. Chemical engineers tell us that charcoal formed at comparatively low temperature is much more hazardous than that made at high temperatures. In fact, under proper conditions such charcoal may be self-igniting, and this naturally gives us good reason for repeatedly urging that all steam pipes be kept clear at all times.

*Outline of talk before the Wisconsin State Dyers and Cleaners Association.

I have asked firemen and others to give me their opinion as to the location of the greatest hazard in dyeing and cleaning establishments, and the answer invariably has been, the wash room or the dry room. I do not have to tell you why we may consider these two rooms as being most feared. You all have a more or less wholesome respect for some of the characteristics of naphtha or gasoline, and I have no doubt that much of my talk will be an old story to you. If you are of this opinion, remember that I am going on the theory that while familiarity may breed contempt, repetition may finally drive home truths that may result in saving life as well as property.

I will not attempt to go into a technical discussion of the various characteristics of the petroleum product most generally used in dry cleaning, but will briefly outline the reasons for treating this material with proper respect. Gasoline and naphtha are general trade terms for various combinations of hydro-carbons obtained from crude oil, and on account of their well-known characteristics have served us usefully and at the same time have, in following the laws under which they exist, caused much grief and loss.

Readily flammable, the solvent most generally used in the dry cleaning process may always be depended upon to respond to any form of ignition. On account of its volatility, it is ever ready to mix with the air to form explosive mixtures, and as the vapors are heavier than air we can not expect ordinary methods of ventilation to carry them away. Granting that this liquid is hazardous, what may be done to reduce the chances for fire or explosion and to provide for the extinguishment of fire should it occur? The most obvious precaution to take is to reduce the exposure of the liquid to a minimum when necessary to expose it, or fabrics saturated with it, then to use every possible precaution to prevent ignition.

Gasoline, its vapors or vapor-air mixtures, may be readily ignited in many ways. Open flames of any kind in the same room, or even in communicating rooms, will certainly cause disaster. Matches carelessly dropped will certainly furnish sufficient heat if stepped upon to ignite the vapors which naturally seek the floor level. Sparks from electrical machinery or wiring have been the cause of many gasoline fires, and static electricity, although scouted by some, has undoubtedly been the factor in many fires for which the reports state that the cause of ignition is unknown. Sparks from outside sources may also be the cause of some of our mysterious fires, and again referring to steam pipes, it is not inconceivable that the self-igniting charred material previously mentioned may be a source of danger. Gasoline vapor may be ignited by sparks caused by striking a shoe nail against flinty concrete aggregate.

Particular attention must be paid to the location of all sources of open flames. All boilers or furnaces must be kept as far as possible from any room in which gasoline is handled and from the outlet of any ventilating system from which vapors may be discharged. Gasoline vapors have been known to travel great distances, and while it is no doubt true that to obtain conditions similar to those which were reported in the Ardmore disaster a large quantity of vapor must be rapidly evolved, we must remember the characteristics of the material with which we are dealing and take proper precautions. It may seem absurd to suggest the use of "NO SMOKING" signs in the wash or dry room of a dry cleaning

plant, but I have seen so many careless practices on the part of thoughtless workmen that I recommend signs in abundance and strict rules regarding the carrying of matches. I have known of instances of matches being found on the floor of dry rooms, and the matches were not of the type which do not ignite when stepped upon. If you believe that your workmen may not observe your rules against carrying matches into hazardous locations, furnish them with the so-called "strike-on-box" safety match. This type of match will, of course, furnish ample heat for ignition of gasoline vapors if deliberately ignited, but if a match is dropped it will not be the same potent source of trouble, when least expected, as is the ordinary "strike-anywhere" match.

Have all electrical motors or other spark-emitting devices located outside the wash room or dry room, and remember that switches should be classed as spark-emitting devices, and, accordingly, must be located outside, and preferably as far above the floor as possible. It is no doubt true that the location of a motor at the ceiling rather than at the floor level has prevented many serious fires.

I am not at all sure that dry cleaning plants are troubled with flies, but if you will all guard as carefully against this well-known pest as is recommended by authorities on hygiene, you will effectually prevent the admission of stray sparks from the outside. Bonfires are often carelessly started by the small boy, and it is also true that the wooden shingle, when ignited, may be carried for long distances. I recommend that a somewhat better screen installation be made for the dry cleaning establishment than is often used in the home, and, obviously, give preference to metal frames and copper or brass wire mesh.

In my previous reference to static electricity I spoke confidently of its possibility, and I wish that I could as confidently point the way to its elimination or nullification. The possibility of producing static discharges under conditions normal to dry cleaning has been demonstrated. Sparks have been collected from belting and gasoline vapors have been ignited by agitating woolen fabrics in gasoline and then lifting the material from the liquid with the bare hands. No doubt the experiment was more or less painful. Authorities tell us that a cold, dry day is particularly conducive to the formation of static discharges, and one investigator has attempted to classify the various factors entering into this particular phenomenon. I find he has suggested a number of plausible factors which may be of interest, and they are as follows: content of moisture in the fabric; moisture in the air, dust in the air, temperature of the air and of the liquid, and the physical qualities of the liquid itself. This particular investigator reached the conclusion that wool is more liable to possess the necessary qualities for the production of a static discharge than cotton or silk, and advances the interesting theory that fillers or dressings used in connection with the latter fabrics have a tendency to attract moisture, and hence reduce the possibility of collecting a static charge of sufficient amount to cause ignition.

It is stated as a fact that under summer conditions of humidity and temperature there are less fires caused by static electricity than under winter conditions, and perhaps this may give a clew as to what may be done to reduce the hazard. At present some believe that all machines should be made of metal and that each machine should be electrically

grounded. Others hold that these particular precautions are unnecessary, and in the case of experiments made by the investigator previously mentioned, fires were obtained where metal vats were used. I am inclined to favor the use of all metal machinery and complete grounding, but, in addition to this, I would provide each machine with an automatic self-closing cover.

I have previously mentioned the reduction of the exposure of gasoline to a minimum, and now I wish to expand on this item in a general way. It is possible that most of the plants which you have in this territory are already well safeguarded. I have not had the pleasure of visiting any dry cleaning establishment in the State of Wisconsin, and I may be doing an injustice when I remark that all handling of gasoline by pails should be immediately discontinued. I have found otherwise well designed establishments equipped with a hand-filled glove-washing machine. Why not go the whole way and have your gasoline supply underground and conveyed from point to point by means of piping? Each machine which may contain gasoline should be connected by piping to an underground storage tank and the piping should be protected against clogging by a system of strainers and valves that will enable the operator to handle the liquid under all conditions with a minimum of exposure. Avoid gravity-feed tanks, and make it a regular practice to leave no gasoline above ground when the plant is shut down, overnight not even excepted. Spotting and sponging often is done in such a manner as to involve the use of open pans of gasoline.

The question of extinguishing a fire in a dry cleaning plant after once started is, of course, a warmer one than what to do to prevent the fire. You will find in one of the sections of the model inflammable liquids ordinance of the National Board of Fire Underwriters a steam extinguishing system satisfactory to the chief of the fire department is suggested, and where steam is not available an approved system using a fire-deterrent chemical or gas. Without intending to encroach on any prerogative of your fire chiefs, I will point out a few of the requirements which have been put into effect by ordinance in the City of Chicago. Steam, if used, is to be supplied by independent piping of ample size, and the source of supply must be on a basis of one horse-power for each 100 cubic feet. It is required that a steam outlet shall be placed over each machine, and that control valves be located outside of the room to be protected.

It is obvious that steam to be fully effective should be confined, and this naturally calls for some method of closing windows or doors left open for ventilation and for shutting down the ventilating systems.

The windows and skylights may be provided with automatically closing devices, but these should be as sensitive as possible, and it would not be amiss to provide for a positive manual control as well and to locate the control station near the steam valve control. Employees should be instructed as to the procedure to be followed in case of fire, and one man should be assigned to the steam valve control station, with proper arrangement for substitutes in case of emergency.

One approved hand-chemical extinguisher is specified for each 500 sq. ft. of floor area, and by reference to the List of Inspected Mechanical Appliances published by Underwriters' Laboratories you will obtain

information as to the type of fire extinguisher particularly adapted for the purpose.

There are two principal types of extinguishers which have been recognized as being of material value in connection with fires in hazardous liquids. The one which has been on the market the longest is the one-quart extinguisher which employs liquid having carbon tetrachloride as a base and which depends upon the blanketing effect of the gas produced when the very volatile liquid is thrown upon the fire. You, no doubt, are familiar with the general characteristics of this device, but I wish to bring to your attention the fact that the limitations of this, as well as of any first-aid fire appliance, must be recognized, and the fact that the device has been recognized as a fire extinguisher must not be taken to indicate that it will control any kind of fire no matter how great the quantity of hazardous liquid involved may be, and what is even more important, it must not be anticipated that this device, or any other device, will put out a fire unless it has been properly maintained. Any device to be operative when needed must be given attention at suitable intervals, and while it may seem unnecessary to point out the fact, field experience has demonstrated that we cannot repeatedly use these devices and expect them to contain a full charge of liquid, when needed in an emergency, unless they have been refilled, or the used liquid replaced each time they are operated. Do not expect these devices to perform miracles. They are designed for incipient fires in limited quantities of hazardous liquids, such as are used in dry cleaning establishments, but they are not, like the "widow's cruse," capable of indefinitely delivering a stream of extinguishing liquid. They must be refilled and they must be kept in proper condition, and when refilled should be refilled with the liquid furnished by the manufacturer, rather than with liquids the nature of which may be unknown and which may involve ingredients liable to cause corrosion, or which may not be suitable for fire extinguishing purposes or suitable to resist the same low temperatures as that required for the liquids used in labeled one-quart fire extinguishers.

The other type of extinguisher is the foam extinguisher. The foam type of extinguisher, which is now being labeled by Underwriters' Laboratories, is of the 2½-gallon size, and depends upon a solution of aluminum sulphate and a solution of bicarbonate of soda, in which is mixed a foam-producing ingredient. When the two solutions are brought together by the inverting of the extinguisher, the chemical action results in the formation of carbon dioxide gas, which, being under pressure, expels the mixture of the two solutions in the form of a foam which, being lighter than oil, will float on the surface and effectually blanket the fire. These devices require attention just the same as any other fire extinguisher, and owing to the fact that they will freeze at approximately the freezing point of water, must be protected from low temperatures, or, rather, must be maintained at a temperature of at least ten or fifteen degrees above the freezing point of water.

A brief summarization of the preceding may serve to concentrate your attention on the general precautions to be taken.

Reduce the exposure of flammable liquids.

Provide an adequate system of ventilation so as to remove flammable vapors as rapidly as they are formed.

Eliminate all possible sources of ignition.

Provide the best possible means for extinguishing fires and give your fire extinguishing equipment such frequent attention that you will know that it is being maintained in a condition ready to properly serve you in any emergency.

Tests of Methods of Extinguishing Fires in Dry Cleaning Plants.

By Goodwin Lee.

(Member N. F. P. A.)

At the convention of the Eastern Association of Master Dyers and Cleaners, held in Atlantic City, a very interesting series of tests to demonstrate various methods of extinguishing fires in dry cleaning establishments were made. Mr. Thomas P. Endicott, Chairman of the Committee on Tests, used his own business establishment for this purpose, and the tests were made under actual working conditions.

As he practically set fire to his building his insurance was previously cancelled, hence he ran the risk of material loss in case of failure of any of the devices under test. This spirit of sacrifice to the safeguarding of the dry cleaning industry cannot be too highly commended.

Appended is a resumé of the tests:

TEST No. 1 was conducted to determine the efficiency of automatic closing covers for washing machines. A washing machine of the usual type with perforated brass cylinder was charged with 30 gallons of 90 per cent benzol; this machine was provided with connections permitting the introduction of carbon tetrachloride and foamite, it being the intention to introduce either of these two extinguishing agents in case the automatic closure of the cover failed to extinguish the fire.

The metal used in the construction of the link had a fusing point of 155 degrees Fahrenheit; the fusible link was attached to the cleaning machine by means of a metal chain, the link being located about 4 feet above machine; a metal plunger or weight was provided to insure tight closure of the cover upon fusing of the link. The test was conducted under ordinary conditions of operation, the machine being located in the dry cleaning room at the plant, operated by Mr. Endicott, Chairman of the Committee on Tests. All windows and doors were closed. The fire was lighted at 3:30—30 and the link fused, tripping the cover at 3:30—50, or in other words 20 seconds after lighting the fire. The fire was apparently extinguished simultaneously with the closing of the cover. This test demonstrated the efficiency and desirability of automatically closing covers, not only for cleaning machines but for extractors as well.

TEST No. 2 was conducted to determine the efficiency of carbon tetra-chloride in connection with the extinguishment of fires occurring

in cleaning machines with cover remaining open. As previously stated, the machine was fitted with a connection permitting the introduction of carbon tetra-chloride by the opening of a remote control valve. All windows and doors were closed. The fire was lighted at 3:45—20; carbon tetra-chloride was turned into the machine at 3:45—35 or 15 seconds later; fire was out 3:45—46 or 11 seconds after the introduction of the extinguishing agent.

TEST No. 3 was designed to determine efficiency of steam for fire extinguishing purposes in dry cleaning rooms. For this purpose, three one-inch pipes attached to the ceiling and running lengthwise in the room were provided; the pipes were perforated, containing 216 one-quarter-inch openings; 110 pounds pressure was carried at the boiler. All doors and windows were closed. The carbon tetra-chloride was still in the cleaning machine, but had sunk to the bottom, the benzol about three inches deep floating on the top. The fire was lighted at 4 o'clock; steam was turned on 8 seconds later. By close observation, it was apparent that as clouds of steam came in contact with the flames, the latter subsided but were not extinguished. After a 2-minute interval as the fire was still burning, and in order to prevent damage to the machine, foamite was introduced, which extinguished the fire practically instantly.

TEST No. 4 was simply a demonstration by the foamite company of the sprinkler head developed in conjunction with the Grinnell company for use in connection with foamite. This head appears to be an adoption of the Grinnell head with separate openings for pipe connections for the two solutions used in the foamite composition. This head is constructed with a perforated inverted umbrella-shaped hood about 4 inches in diameter placed directly above it. For purposes of the test, four uprights were erected and covered with a plank roof, covering an area of approximately 25 square feet, and duplicating a section of a ceiling. Tanks were placed on the ground directly beneath and the head located approximately one foot below the ceiling; compressed air was used as the expelling agent. The demonstration would appear to indicate that there is considerable merit in this head, but the uneven distribution of the foam indicates that a new standard spacing of heads will probably have to be established.

CONCLUSIONS.—From these tests it is obvious that, singly or in combination, the foregoing methods of fire extinguishment can be employed safeguarding the hazard of dry cleaning to a very marked degree. Probably the most impressive demonstration was the effect of the automatically closing cover on the washing machine. It would seem desirable in the compilation of regulations to make the use of such an equipment mandatory for machines and extractors.

From the results obtained by the steam, it would appear that much is to be learned as to the desirable size of pipes, pipe openings, the volume of steam introduced and proper pressure to be carried at the boiler. Probably some standard could be worked out specifying the volume of steam necessary for rooms or spaces of various sizes with residual steam pressure at the boiler of prescribed minimum.

From these tests it is apparent that carbon tetra-chloride and foamite are especially efficient in extinguishing fires in partially closed compart-

ments. The experimental sprinkler head for foamite appears to be meritorious and would seem to indicate extensive possibilities for foam protection through sprinkler systems in buildings of hazardous occupancies.

Dry Cleaning Establishments—Fire Record.

Reports of fires in dry cleaning establishments are notably lacking in details. "Explosion of gasoline—loss slight" is a frequent story. Out of 130 fires classified in the table following, 104 or 80% entailed a loss under $5,000 and in most cases trifling, as the greater proportion of these fires are usually confined to the room, machine or tub in which they originate. Nor is it surprising to note that the direct cause for over 50% remains unknown, when one considers the sudden outbreak and frequently the explosive violence which attend fires of this class.

Although, as said in the preceding paragraph, the losses reported on dry cleaning establishment fires are on the whole small, this fact should not be regarded as a criterion of the hazards involved. The small losses reported may be accounted for by the fact that many of the fires reported have occurred either in large modern establishments provided with all safeguards and fire extinguishing apparatus such as steam jets, where the safeguards function properly and hold the fire to a small loss; or else they have occurred in small old fashioned plants without modern apparatus, where the property values involved are so small that the losses are not large in money value, even though the building and contents are a total loss, as is the case in a number of the reports.

The life hazard in dry cleaning establishments seems to be more serious than the possibility of property damage. Explosions or quick spreading fires of the flammable liquids used may easily result in loss of life or in severe burns, before employees have time to reach even nearby exits. This further emphasizes the importance of proper automatic safeguarding devices. It is a significant fact that the three loss of life fires reported were all explosions, and that all persons in the room or building lost their lives, leaving no evidence as to the cause of the fire.

In several cases, for lack of a better cause, fires have been attributed to the ignition of matches in pockets of garments during the cleaning process. Static electricity is credited with having caused nine fires and in all probability a considerable portion of the outbreaks of unknown origin might well be attributed to this phenomenon peculiar to silks or woolens involved in the cleaning process. Of the seven fires caused by pressing irons, two were due to the ignition of gasoline fumes from the exposed flames in the gas heated variety.

Most of the fires in this class of property are of a special hazard nature. The indirect cause of 80% of the fires recorded can be traced to the use of such flammable cleaning liquids as gasoline, benzine or

naphtha. Almost 70% of these special hazard fires are associated with the cleaning process as conducted in open receptacles. Mechanical cleaning in enclosed machines apparently reduces this hazard 84%.

Only five fires are recorded as taking place in sprinklered properties. It is of interest to note that the effect of sprinklers was to practically extinguish the fire in each case. One head operated at three of the fires; five and eight at the other two.

The following is compiled from fire reports on file in the N. F. P. A. Department of Fire Record:

Dry Cleaning Establishments—Fire Record.

(Tabulation of 130 Fires.)

		No. of Fires	Per Cent of Fires
LOSS			
	Large	13	10.0
	Small	104	80.0
	Not Stated	13	10.0
		130	100.0
CAUSE			
	Unknown	68	52.4
	Matches	13	10.0
	Static Electricity	9	6.9
	Stoves and Furnaces	8	6.2
	Pressing Irons	7	5.4
	Sparks	7	5.4
	Spontaneous Ignition	5	3.8
	Miscellaneous	5	3.8
	Friction	4	3.1
	Open Flames	2	1.5
	Overheated Dryer	2	1.5
		130	100.0
CLASSIFICATION			
	Special Hazard (gasoline, benzine, naphtha)	110	84.6
	Common Hazard	20	15.4
		130	100.0
PROCESS			
	Cleaning—open	76	69.1
	mechanical	12	10.9
	Drying —open	11	10.0
	mechanical	11	10.0
		110	100.0
EXPLOSIONS		36	
LIVES LOST		9	

Abstracts from Fire Reports.

The following are typical abstracts from reports, and are intended to illustrate the general character of the reports summarized in the foregoing table:

H-1227. Explosion, probably of gasoline still in brick building, was immediately followed by fire. All the occupants of this plant, totalling six in number, lost their lives.

H-3893. Fire occurred in naphtha house. Just prior to outbreak a rotary washing machine of the ordinary laundry type, constructed of galvanized iron, was in operation cleansing a silk gown which had metallic trimmings. The machine was stopped, opened, and as employee reached for dress the naphtha caught fire. It is probable that friction in silk garment had charged the metallic trimmings with static electricity, and that the hand of the employee furnished a means of discharge; the spark formed igniting the naphtha fumes. This fire was extinguished by steam with practically no damage to building; safety covers, drains to tanks and ventilators all working properly.

H-6426. Fire occurred in one-story brick building with cement floor and open joist ceiling. Employee was cleansing dress in a pail of naphtha. Garment was of wool with silk lining, and rubbing together caused electric spark which ignited the naphtha. Fire extinguished with small loss.

H-6693. Employee was wringing gasoline from silk garment when fumes were ignited by electric discharge. Flames spread to basin of gasoline. Employee was burned and floor and roof of building damaged considerably.

H-6995. Violent explosion occurred in dry room of building of light fire resistive construction. Two employees were killed outright; building completely wrecked and all windows in immediate neighborhood shattered. A slight fire followed.

S-12109. Gasoline became ignited in washing machine upon removing cotton and woolen goods from same. One sprinkler opened, and with aid of steam jet, fire was extinguished before arrival of department.

H-13839. Employee was hanging up gasoline saturated silk garments in dry room (fire-resistive construction) when one piece dropped on concrete floor. In picking up same the man heard a sound like a static electrical discharge. The clothing immediately burst into flames. Fire extinguished by employees with two soda acid extinguishers. Damage confined to clothing.

S-14785. Woolen garments became ignited while in extractor. Machine was slowing down after power had been turned off. Fire extinguished by operation of one sprinkler, assisted by steam jet and employee with two and one-half gallon extinguisher.

H-16490. An explosion, immediately followed by fire, completely destroyed a small frame building, causing the death of the owner who was working alone inside at the time. Cause laid to habitual smoking.

Another Steam Pipe Fire.

Report by H. E. Drugan.

(Member N. F. P. A.)

It has long been a well recognized fact that low pressure steam pipes are the cause of a large number of fires, but specific, well substantiated instances of such fires are not so numerous. A fire in the Wesley Block, Columbus, Ohio, on November 15, 1920, furnishes an excellent illustration of the way such fires may occur. The building is a large brick structure of old style ordinary construction, occupied for mercantile and office purposes, including light shop craft work.

The fire was discovered under the second floor, and smoke was coming out from under the floor above, having traveled up the inside of partitions. Both floors are of matched tongue and grooved dimension lumber, and are covered with linoleum, which fact would eliminate the "dust and sweepings" theory as a possible explanation of the cause of the fire. Upon tearing up the floor it was discovered that woodwork around a steam pipe leading to an ordinary office radiator was on fire. Because of quick discovery and prompt action the fire was extinguished by the use of a 2½-gallon chemical extinguisher.

An examination showed that no attempt had been made to insulate or protect the woodwork from the steam pipe. There were very evident signs of smouldering and charring on the under side of the floor, and on the floor joists for several feet around the steam pipe. This had apparently been going on for some time. The heating system is low pressure steam, installed about twenty-five years ago. If further evidence were needed to definitely prove that the low pressure steam pipe was responsible for this fire, it would be furnished by the fact that a similar fire occurred in the same building about eight years ago.

Clearance and air circulation should be allowed between all steam pipes and woodwork.

Newcomb Theatre Film Fires, New Orleans.

Report by Louisiana Fire Prevention Bureau.

(Member N. F. P. A.)

This small moving picture theatre located on the first floor of this three story brick building has had a series of film fires. One fire occurred Saturday, November 6th, 1920, at 12:55 A. M. and another the following Monday, November 8th, at 10:30 P. M. The owner claims that the fires were caused through carelessness on the part of the operators and the operators in turn accuse the owner of negligence. We propose to give the facts as we see them in the following report and will refrain from offering criticism. It might be well to state in advance, that other film fires in this theatre were recorded January 2nd, 1920, and November 9th, 1917, and thanks to the fireproof booth and automatic sprinklers, the building and audience has escaped so far without injury.

There are two motor driven Simplex moving picture machines in the booth, the machines having been at one time standard but now presenting a dilapidated appearance. So many parts are broken, missing or unused, that it would take considerable space to describe this in detail. Fourteen National Electrical Code violations were noted on this superficial inspection, all of which violations are active fire hazards.

The owner would not give any reason for accusing the operators of carelessness and simply made the assertion for what it was worth, assuming that without a certain amount of carelessness, fires would not occur; this is a very broad view and can be applied to almost any class of accident and unless some specific action that can be described as carelessness can be shown, we would prefer not to dwell further on the owner's testimony.

Both operators claim in their statements that the fires were primarily due to defective films (films with defective perforations). When such films are used in defective machines, that is machines with the gates or other parts missing, fires are to be expected. We are inclined to agree that this is a very important matter, but during the visit of the writer to the booth, the lower reel stopped revolving and the film left the sprocket and ran out on the booth floor through the open gate near the aperture plate; instead of immediately stopping the machine, the operator attempted to wind the film on the lower reel by hand and failing in this, broke off the film, took out the lower reel, inserted another empty reel in the lower magazine and again started winding the film on this reel by hand; during this time over 150 feet of loose film was scattered over the booth floor with all magazine doors open, in fact the magazine doors were not kept closed at any time the inspectors were in the booth. The operator offered no excuse whatever for not stopping the machine and simply stated "that he never lost his head in an emergency."

Undesirable Features.

1. There are two motor-driven machines in this booth attended by only one operator who also does the rewinding after the films are shown.
2. The booth is so poorly ventilated that the booth door must be kept open to furnish fresh air.
3. Arc lamp housing damaged.
4. Picture machine in bad repair and some parts missing.
5. Circuits extended with flexible cords.
6. Armor of cable not properly attached to fittings.
7. Junction box covers missing.
8. Doors missing from switch and cut-out cabinets.
9. Joints in flexible cords not approved.
10. No rewinding magazines.
11. Fuses too heavy.
12. Fuse gaps bridged.
13. Cut-outs in bad repair.
14. Wires show excessive heating.

NOTE: The installation in booth and where other defects exist needs a general overhauling; only such deficiencies are listed above as are considered active fire hazards.

Conclusion.

It will be seen that the owner has not sufficient control over his operators or has neglected to instruct them in the importance of fire prevention. One operator in a booth attempting to run two machines and rewind films is not in a position to do his work properly at all times.

The booth is not properly designed so as to afford sufficient ventilation and is therefore operated with the booth door open.

Films are used that should be scrapped and the moving picture machines are poorly kept up.

Finally, little if anything can be said of a favorable nature about the operation of this theatre.

Pyroxylin Plastic Storage Vault Fire.
Comb Works, Brooklyn, Nov. 4, 1920.

Report by New York Fire Insurance Exchange.
(Member N. F. P. A.)

The plant consists of a main sprinklered two story building of ordinary construction; also several one story frame buildings in yard to the North and two sprinklered pyroxylin plastic storage vaults of fireproof construction located in yard 20 feet distant from main building and a frame unsprinklered shed located in front of vaults. Vaults are divided with a 12-inch brick wall.

The fire occurred in the South vault, which is 22 feet 11 inches long, 18 feet 4 inches wide and 9 feet 10 inches high, with a capacity of 4,100 cu. ft. and is constructed of 12-inch brick walls and 4-inch reinforced concrete roof. This vault is provided with a pressure relief vent in the southwest corner through a vent shaft, constructed of brick, extending 15 feet above roof and equipped with metal hood at top; also a window of thin glass in wood sash at bottom. The effective area of the pressure relief vent is 2,640 square inches. The vault has manually operated inner and outer vault type doors at the egress opening and the stock was placed on metal shelving at sides.

There were 5, fixed, incandescent electric lights, extending 15 inches below ceiling and controlled by switch located inside the vault. The vault was heated by exhaust steam with a pressure of from 1 to 2 lbs.; the steam coils being located on south wall and extending from floor to a height of approximately 3 feet above. It is claimed the coils were protected by a metal screen. There were six automatic sprinklers, Globe "B" type, installed in 1916, connected by means of a 2-inch pipe with the sprinkler system in the main factory, supplied by city water at 40 to 45 lbs. and a 10,000 gallon gravity tank.

The sprinklers were spaced 7 x 8 ft. without baffle plates between.

Occupancy.

At the time of the fire each vault is said to have contained approximately 2,500 to 3,000 lbs. of pyroxylin plastic in the form of sheets, rods and tubes, also some finished articles, about evenly distributed on shelving. The greater part of this stock was stored in wood boxes. In the South vault there was also some horse hair and a stock of chemicals consisting

of amyl acetate, denatured alcohol, sulphuric ether, sulphuric acid, black and brown dip and one barrel of bleach. The quantity of these chemicals is said to have been small and kept in metal cans and glass bottles.

Story of the Fire.

The fire was discovered by an employee who was in the vault at the time, preparing parcel post packages for mailing. The cause was not definitely ascertained but it is supposed to have been caused by pyroxylin coming in contact with steam coils. The employee who first discovered the fire stated it originated on the floor at south wall where steam coils are located and that he had noticed previous to the fire breaking out a hissing noise which he supposed was caused by steam in the coils. Shortly after this a cloud of smoke came up in his face, then an explosion which threw him out of the vault. This employee was not burned but had scratches and bruises on various parts of his body. Another employee pulled a street fire-alarm box and the Fire Department and Patrol responded promptly.

It is claimed the vault doors were open when the Fire Department arrived and one of the firemen closed but did not bolt them. Almost immediately after closing doors another explosion occurred which blew the doors open and two firemen were sufficiently burned to make it necessary to take them to the hospital. The explosions referred to are believed to have been puffs, as there is no evidence of any disarrangement of the equipment in the vault.

The Fire Department put two hose lines in operation from a steamer, one through doors and the other through a hole which they broke through south wall of vault. These hose lines are said to have been in operation for approximately 30 minutes.

All of the six sprinklers in the vault operated for a period of approximately 30 minutes, with an estimated discharge of 5,400 gallons. From the appearance of water marks on ceiling, also the thick carbon on the surface of the metal shelving, which was slightly warped due to heat, it is evident that the water flow from the sprinkler in N. E. corner of vault was partly obstructed by some foreign material.

Damage.

While not more than fifty per cent of the pyroxylin plastic stock was actually destroyed, that remaining was so discolored and otherwise injured as to be unsuitable for manufacturing purposes. The horse hair and many of the chemicals appear to have been but slightly damaged.

Apparently the vault is not damaged except that the wood sash in pressure relief vent was partly burned and electric light wires at ceiling were damaged.

The North vault including contents was not damaged.

Conclusions.

1. That sprinklers of sufficient number with adequate water supplies will control fires in properly segregated stocks of pyroxylin plastic.
2. That injury to the two firemen probably would not have resulted had vault door been closed and bolted and sprinklers left to extinguish fire.
3. That heating pyroxylin plastic storage vaults is a dangerous practice except by properly guarded hot water pipes at ceiling.

Fires in which there was Loss of Life.

These notes are intended to point out conditions under which loss of life has occurred, that they may be known and guarded against.

H-16354. Dwelling. The mother of four children went to a store, leaving the children alone locked up in an ordinary frame dwelling house. The father was also away, at work. Fire started in the kitchen, either from the kitchen range which is known to have been burning when the mother left, or from the children's playing with fire. Smoke was discovered coming from a second-story window, an alarm promptly given, and a quick response made by the fire company. The smoke was so dense, however, that the firemen could not get inside until after more than an hour, not being provided with smoke helmets. There was not much fire at any time, and when the bodies of the four dead children were reached, they were found not much charred, but badly discolored by smoke and water. It is evident that they were suffocated by smoke rather than burned to death.

Children should never be left alone in a house and especially not locked up.

H-16390. Wholesale Furniture. A kerosene stove used for heating glue pot in the finishing room overturned and took fire. The employee who discovered the fire remained too long in attempting to extinguish it with a chemical extinguisher, and could not reach the fire escapes as their entrances were blocked by stock.

Fire escapes should be easy of access and be always kept clear of all obstructions.

H-16448. Oil Refinery. This building was of brick, two floors, wareroom first floor front; boiling room back of first floor. Offices on second floor. The process, which was in operation, was the boiling and mixing of animal, fish and petroleum oil by fire heat. Vapor from the boiling oil took fire and spread to surroundings, and through an opening in a division wall where a fire door was attached but was left open, allowing the fire to extend to the front and to the stairway. The workmen all escaped, leaving the office force on the second floor, who had to risk the stairway, by which exit some escaped, while others had to jump from windows to a shed. One was overcome on the stairway and was burned to death. Another with clothing all afire jumped from a window and died from burns. The building and machinery were destroyed.

Three of the office force were girls. Two were led down the stairs safely. The other not appearing, an employee ran up and found the girl sitting on a chair amidst the smoke. She had lost all control of mind, but was dragged down the stairs unharmed.

Fire doors in such hazardous occupancies should be automatic. Adequate duplicate exits should always be provided from upper floors.

H-16403. Chemical Works. This fire originated in one of two tanks in yard where naphthaline was being treated by heat from steam coils in the tank. The fire is supposed to have originated from a leak in a steam pipe in the tank, creating a pressure which ruptured the top of the tank. The naphthaline vapor ignited from fires in the boiler house a few feet away. The fire immediately enveloped the other tank and adjacent buildings. One of the employees was caught in the boiler house and was burned to death.

Tanks of flammable liquids should always be properly vented, and should be located well away from all fires.

H-16343. Dwelling. The cause of this fire was unquestionably from the use of gasoline which had been procured by Mrs. Rupe of Frankfort, Indiana, at a filling station operated by the Standard Oil Company. In all probability she had requested her kerosene oil can be replenished, but through mistake gasoline was delivered, although because of her death this cannot be positively substantiated. About four o'clock in the afternoon of June 5, 1920, in order to replenish the fire in the heating stove which had practically gone out, she saturated the smouldering fire with what she supposed was kerosene oil. However, the appearance of the entire premises indicates clearly that it was gasoline. The woman lost her life, being burned to death in the room where the heating stove was located. Her little baby in the adjoining room also was burned to death. The entire interior of the little four-room dwelling showed evidence of a very quick flash fire, necessitating the removal of all the casings and window frames. Other than this there was no damage to the building. Investigation was made by the coroner as to the mistake in delivering gasoline instead of kerosene oil, but as the wife lost her life immediately it could not be determined whether she requested gasoline or kerosene, although the can was a nonstandard gasoline can and was not of the required red color.

Extreme care should be exercised to avoid confusing gasoline with kerosene.

H-16357. Dwelling. Mrs. F. M. Shermak of 1324 K Avenue, Cedar Rapids, Iowa, died and her husband suffered severe injuries as a result of burns received when a flammable polishing material being used by Mrs. Shermak on the kitchen stove in their home "exploded" and set fire to her clothing.

Thinking that the fire in the stove was entirely dead after dinner, Mrs. Shermak had placed the can of polish on the top of the stove and started work. She had about finished and was bending over the lids when the flammable vapors ignited with a flash. The top of the stove became a mass of flames which spread instantly to her clothing. Her husband after several attempts extinguished the fire by wrapping a blanket around her, but not until he had been severely burned himself and she had sustained burns which resulted in her death a few hours later.

Such flammable polishes should never be used even on stoves where the fires are apparently out.

H-16367. Saloon, occupied as dwelling. Two men in the cellar

were handling a demijohn containing grain alcohol. The demijohn was accidentally broken, the resulting alcohol fumes, igniting from an open gas light, exploded killing one of the men instantly and resulting in the death of the other afterwards from burns and shock. As no evidence could be procured as to the intended purpose of the alcohol, it is inferred that it was to be used for illegal purposes.

Flammable liquids should never be handled in proximity to open flames.

H-16334. Salt Mine. Workmen were painting the mine shaft of a salt mine at Jefferson Island, Louisiana. They were working about ninety feet down painting with a gasoline and creosote paint. According to the ante-mortem statement of one of the men, one man struck a match intending to light a cigarette, fumes in the shaft ignited and there was a flash fire which burned six men hopelessly. The fire lasted only a short time and the damage to the shaft was slight. Two men were instantly killed and the other four died in a few hours.

It should be unnecessary to point out the criminal carelessness of using matches when working with gasoline in confined spaces.

H-16403. Dwelling. A lamp left burning at night started fire which made such headway that before the family awoke or anyone discovered it, three children were burned to death in bed. One child and the father and mother reached the outside, but were so badly burned that they died in a few hours. The total loss of life was six, four children, and the father and mother.

The hazard of unsupervised and defective kerosene lamps should be well known, especially in flammable dwellings liable to quick burning fire.

H-16382. Mercantile. A large gasoline tank was being cleaned while a blacksmith forge was in operation near the tank. The gasoline fumes ignited at the forge and flashed back to the tank, resulting in the death of two men who were engaged in the cleaning process.

Open flames of any kind should never be allowed near gasoline storage.

H-16431. Dwelling. This fire occurred in an upstairs bedroom in a two-story frame farmhouse. The owner had taken in a pauper from the county poor farm, who is supposed to have gone to bed and fallen asleep while smoking. An attempt was made to rescue him from the flames, but without success and he was burned to death.

Smoking in bed is extremely hazardous.

Points of Interest from Fire Reports.

These notes are selected to illustrate conditions making for or against the effective control of fire.

S-24601. Mercantile. Fire occurred on fifth floor from an electric pressing iron left "turned on." One sprinkler extinguished fire. The supervisory system water flow alarm failed, due to relay in transmission box sticking, and failed to register low water in gravity tank due to seal over float sticking. As no watchman was employed on the premises, the sprinkler operated until both pressure and gravity tanks were drained. Central station received a "low air pressure" signal, but did not notify engineer until following morning at his home. He arrived at the building about 9 A. M. and notified insurance patrol. About 19,000 gallons of water used from one head in operation under 100 lbs. pressure. Very large water damage.

S-24692. Mattress Factory. A small piece of metal in stock struck a spark from the teeth on rolls, igniting cotton and spreading along aprons of garnetting machines in both directions. Beside the machine is located a bin with a small opening at side provided with an automatic trap door through which the man takes armfuls of cotton for feeding garnetting machine. There is another opening at top of bin with automatic trap door through which the unused material which gathers on second floor during process of shaping quilts for comforters is dropped into bin below. Employees were just cleaning up waste cotton and dropping it through opening when fire occurred. Fire flashed into cotton bin and up through opening to second floor before either trap door was released. The few girls working here immediately ran into the front section protected by a fire door. As soon as last girl was out, door was closed, but fire had already flashed along loose cotton on floor into the front section, igniting a pile of comforters. Sprinklers opened, twelve heads on second floor, which checked fire and practically extinguished it, except in piles of comforters in front section where hose stream was used. The total loss to building, machinery and stock amounted to $22,000.

S-13212. Office Building. Fire occurred on roof of building twelve stories high in a concrete pent house used to house motors, switchboards, rheostats, etc., of the fire elevators in buildings. The fire department was delayed over fifteen minutes in getting a stream of water to roof because threads on outside standpipe and department hose were different, and interchangeable couplings were not to be had. A line of hose was finally run from the street, twelve stories to the roof, and fire quickly extinguished with negligible damage to

building, but considerable damage to elevator apparatus. The standpipes on each floor provided with 2½" cotton hose were entirely overlooked by fire department, due to the inexperience of firemen in buildings of this nature. There is only one elevator attendant on duty in this large building at night, and he must attend to all the chores about engine room, operate elevator, keep up fires in boilers, and in addition be night watchman. He was entirely ignorant of the various fire appliances in buildings, and was unable to give any information to assist fire department.

S-24596. Cotton Mill. A mill hand had collected some card strippings in a high basket, and had started down an aisle, between the cards on second floor, for picker room when the edge of his basket struck an incandescent bulb, which broke in basket, igniting the strippings. The man, unaware of the accident, continued through two fire doors to the picker room, where someone yelled to him that his basket was afire. He promptly dropped the basket beside a pile of 130 laps and ran. The laps ignited at once. At hose stream was quickly turned on fire and with one sprinkler soon extinguished fire with trifling damage.

S-23903. Flour Mill. Employee in charge noticed that belt was slipping and elevator clogged. Instead of shutting off power, he went to ground floor and began to dig out grain. He soon observed smoke, but being unable to locate fire he called superintendent on telephone. Some twenty-five minutes later he arrived and immediately stopped machinery. The sprinklers had prevented extension of fire, and entirely extinguished it as soon as friction was removed.

Fire Departments.

S-25174. Chrome Tannery. Fans in tacking lofts are run all night. At 1 A. M. the night electrician visited the third floor to inspect a new motor recently installed driving a fan, and found it just breaking into flames from overheating. He immediately turned in alarm from fire box in yard. At the same time two heads opened, sending a water flow signal to central station. Watchman also pulled a manual box a few seconds later. The electrician used a carbon tetrachloride extinguisher on burning motor, and with two heads operating quickly put fire out. Damage to motor and water loss in stockroom below adjusted for $2,250. The loft where fire occurred is directly over the finished leather stock and shipping room containing very large values, and a water loss easily fifty times larger would have resulted but for prompt work by firemen and employees, who spread blankets and heavy wrapping paper over leather, doing very efficient work.

S-15440. Cotton Seed Oil Mill. Fire was discovered at 3.22 P.M. in a pile of seed in warehouse "B," supposedly from spontaneous ignition. The fire department responded and apparently extinguished fire. The second fire was discovered at 12.08 A. M. the next morning, no doubt a rekindling of previous fire. Watchman was about to punch his station, located at east end of warehouse "B," when an explosion occurred, followed by a quick fire. When public fire department

arrived warehouse "B" was afire its entire length. Fire spread rapidly to hull house and a new fibre warehouse to the west, due primarily to the highly flammable materials incidental to cotton seed products plants fanned by a brisk southwest wind. The fire department foolishly attempted to check the fire in the already doomed seed house with three inadequate streams, while the fire was rapidly spreading over other buildings. The firemen were unfamiliar with the class of fire they were fighting, and in addition were further handicapped by the fact that the fire had gained such headway before their arrival; also by the difficulty experienced in stretching their hose lines, due to obstructions such as fences and railroad tracks. Loss about $500,000. This fire emphasizes the necessity of maintaining a special guard for a reasonable period after a fire has supposedly been extinguished.

S-24690. Wool Extracting Factory. Fire occurred in picker on second floor, and had been practically extinguished by sprinklers when fire suddenly flashed out on the floor directly above in the room used for oiling down the woolen rags. The floor was badly oil soaked, and the sprinklers were unable to hold the fire, which quickly spread through the opening in brick division walls and opened every sprinkler on third floor. After the fire the sprinkler piping on this floor was found badly warped and twisted, indicating a lack of water on system sometime during fire. Dense smoke compelled firemen to fight from the outside. An excessive water damage to stock resulted through indiscriminate use of streams; actual fire loss small.